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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 618

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER March 13, 1918

EXPERIMENTS WITH DURUM WHEAT

By

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CARLETON R. BALL, Agronomist in Charge, and J. ALLEN CLARK
Scientific Assistant, Western Wheat Investigations
Office of Cereal Investigations

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INTRODUCTION.

Extensive experiments with the durum wheats have been conducted in this country for the last 10 to 15 years. During this period their commercial importance has increased steadily. At first they were regarded commercially with indifference, then with hostility, and finally with approval. Numerous bulletins have discussed their introduction and adaptation and also their value under more or less limited conditions. These publications are listed alphabetically by authors at the end of this bulletin.

The purpose of the present bulletin is to assemble the principal accumulated experimental data on yields of durum wheat in the United States. Many of these data are here published for the first time. Some of them, however, have been published previously in the bulletins cited. The bibliography also includes citations of bulletins containing some results obtained with durum wheat which are not presented here. This bulletin discusses the history of durum wheat in the United States, the statistics of production, the characters and relationships of the important varieties, and the results of experiments conducted at 30 field stations.

SOURCES OF DATA.

The experimental data have been derived from three chief sources, namely, experiments conducted cooperatively by the Bureau of Plant Industry and State agricultural experiment stations, experiments conducted independently by the Bureau of Plant Industry, and, finally, to make the record more complete, experiments conducted independently by various States.[1]

For convenience of discussion the stations from which the data published herein have been obtained are arranged, in the list which follows, in three groups located, respectively, in the subhumid Prairie States, in the semiarid Plains States, and in the arid basins and valleys of the Far West.

Of the data from stations in the subhumid Prairie States, those from McPherson, Kans.; Ames, Iowa; Brookings, S. Dak.; and Fargo, N. Dak., were obtained cooperatively, and those from Manhattan, Kans.; Lincoln, Nebr.; Ashland, Wis.; and St. Paul and Crookston, Minn., were obtained independently by the State experiment stations.

In the Great Plains area data from the following stations were obtained in cooperation with the State experiment stations: Hays, Kans.; Highmore, Eureka, and Newell, S. Dak.; Dickinson and Williston, N. Dak.; and Moccasin, Mont. At Archer, Wyo., the cooperation is with the Wyoming State Board of Farm Commissioners. At Amarillo, Tex., and Akron, Colo., the data were obtained independently by the Bureau of Plant Industry. At Amarillo the Office of Cereal Investigations conducts the station in cooperation with the Amarillo Chamber of Commerce. At Akron the Office of Dry-Land Agriculture conducts the station, and the Office of Cereal Investigations cooperates in the experiments with cereals. At North Platte, Nebr.; Edgeley and Langdon, N. Dak.; Brandon, Manitoba; and Indian Head, Saskatchewan, the data were obtained independently by the State experiment stations or the Canadian Department of Agriculture.

Of the six stations in the basin and valley areas of the Far West, five were conducted cooperatively, namely, Nephi, Utah; Aberdeen, Idaho; Burns and Moro, Oreg.; and Modesto, Cal. The sixth, at Chico, Cal., is conducted by the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, with which the Office of Cereal Investigations cooperates in the cereal experiments.

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[1] The sources of the data from the stations conducted independently by the various States are indicated at the proper points in the text. The men who have been in charge of the cereal experiments during part or all of the years cited, at stations where experiments have been conducted either independently or cooperatively by the Office of Cereal Investigations, Bureau of Plant Industry, are listed as follows: *California.*—Chico, E. L. Adams; Modesto, H. F. Blanchard. *Colorado.*—Akron, W. G. Shelley, Clyde McKee, C. H. Clark, and George A. McMurdo. *Idaho.*—Aberdeen, L. C. Aicher. *Iowa.*—Ames, L. C. Burnett. *Kansas.*—Hays, J. G. Haney, O. H. Elling, A. M. Ten Eyck, C. C. Cunningham, and F. A. Kiene, jr.; McPherson, V. L. Cory. *Montana.*—Moccasin, E. L. Adams and N. C. Donaldson. *North Dakota.*—Dickinson, L. R. Waldron, C. H. Clark, J. A. Clark, and R. W. Smith; Fargo, J. H. Shepperd and O. O. Churchill; Williston, F. R. Babcock. *Oregon.*—Burns, L. R. Breithaupt; Moro, H. J. C. Umberger and D. E. Stephens. *South Dakota.*—Brookings, J. S. Cole, Clifford Willis, and M. J. Champlin; Eureka, M. J. Champlin; Highmore, M. J. Champlin and J. D. Morrison; Newell, Cecil Salmon and J. H. Martin. *Texas.*—Amarillo, A. H. Leidigh and J. F. Ross. *Utah.*—Nephi, F. D. Farrell, P. V. Cardon, A. D. Ellison, and J. W. Jones. *Wyoming.*—Archer, J. W. Jones and V. H. Florell.

The writers gladly acknowledge here the effective cooperation of the several State experiment stations in the conduct of experiments and the courtesy of the directors and their associates, who have furnished data obtained independently by their stations.

HISTORY.

Durum wheat, though a comparatively recent immigrant in the United States, has long been grown extensively in other parts of the world. Southern Russia is the principal producing area. Large quantities are grown also in the Mediterranean region, especially in Italy, France, and Algeria. Smaller quantities are produced in India and in South America, particularly in Argentina and Chile. In Russia the crop is spring sown, but in most of the Mediterranean region, with its mild climate, the crop is sown in autumn.

The first official introduction of durum wheat varieties occurred apparently in 1853. In that year a durum variety, called Algerian Flint (Browne, 1855),[1] was obtained from the Province of Oran in Algeria, and another, called Turkish Flint (Browne, 1855, 1856), from near Mount Olympus, in Asia. The Mount Olympus of modern maps is in European Turkey, not far from Saloniki. The Turkish Flint was described as a black-glumed variety. It was grown to some extent in various parts of the eastern United States and later became known as Mount Olympus and as Olympia wheat (Klippart, 1858). In 1854 a durum variety distributed as Syrian Spring was obtained in Palestine (Browne, 1855), supposedly near Mount Carmel. It appears not to have become cultivated to any appreciable extent. In 1864 an introduction of Arnautka (Reid, 1866) was made, presumably from Russia, and grown in 1865 with other varieties on what are now the grounds of the Department of Agriculture near Fourteenth Street, Washington, D. C. None of these introductions became established as a farm crop.

The next recorded official introduction was made in 1899 (Carleton, 1900, p. 11), followed by still others in the next two or three years. These last-named introductions, from which the crop was really established, were made by Mr. M. A. Carleton, Cerealist of the United States Department of Agriculture. In 1898–1899 and again in 1900 he went to Russia and Siberia for the purpose of obtaining adapted cereal crops. Chief among these introductions was durum wheat, of several varieties, particularly Kubanka.

Introductions of durum wheat had been made by Russian settlers in several States of the Great Plains area and its culture established locally. Additional introductions have also been made by other representatives of the Department of Agriculture and the State experiment stations. However, a strenuous campaign of education led by Mr. Carleton was necessary to fix the commercial status of durum wheat, after which it soon became a staple American crop.

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[1] Reference is made to name and date in the "Bibliography," p. 61–64.

In the meantime deficiencies in the supply of European durum wheat and the activities of Duluth wheat exporters enabled the macaroni manufacturers of the Mediterranean countries to become acquainted with American durum wheat. An export outlet was obtained in this way, which aided greatly in giving the crop some standing among farmers while its commercial status in this country was being established.

Several difficulties were met in the process of establishing the growing of durum wheats on a commercial basis in this country. Chief of these was the fact that there was no market demand for these wheats in America. Macaroni, spaghetti, and other manufactured forms of durum wheat were not generally used, and durum flour was unknown. The durum wheats were an unknown quantity to the grain trade, the milling industry, and the eaters of bread. The kernels were different in size, color, and hardness from those of other wheats grown here and so could not be thrown into the established grades or mixed in granaries, cars, or elevators. They were so hard that mills could not grind them with the equipment and methods then in use, and few millers thought they could afford to spend the time and money for necessary experiments. Much opposition arose, therefore, and the price of durum wheat was depressed below that of common wheat. For the first few years almost no market existed.

Figure 1 shows graphically the comparative market value of No 1 Durum and No. 1 Northern wheat at Duluth, Minn., in the 15 years from 1902 to 1916, inclusive. The value given is the closing price on the first business day of each month during that period.

From this diagram it will be noted that the average spread in price in the nine years from 1902 to 1910, inclusive, was about 15 cents per bushel in favor of common wheat. At the country elevators the discrimination against durum, especially in small lots, frequently was as much as 25 cents per bushel. Under these market conditions much durum wheat was fed to stock on the farms where it was grown.

During 1911 the spread in price gradually decreased, and in the last five years, 1912 to 1916, inclusive, the average price has been about the same. During part of this period the price of durum has been appreciably above that of common wheat.

It must be recalled that the figures for market value at Duluth are always more favorable to durum wheat than those from any other point. Durum wheat which has arrived at Duluth not only is in commercial channels, but often is already en route to an export market, presumably in response to a definite demand. At other terminals, and especially back at the primary markets, as noted above, conditions were much less favorable to this wheat.

AGRONOMIC ADAPTATION AND PRODUCTION.

Durum wheat owes its importance in this country to certain characters which adapt it to the conditions prevailing in parts of the spring-wheat belt.

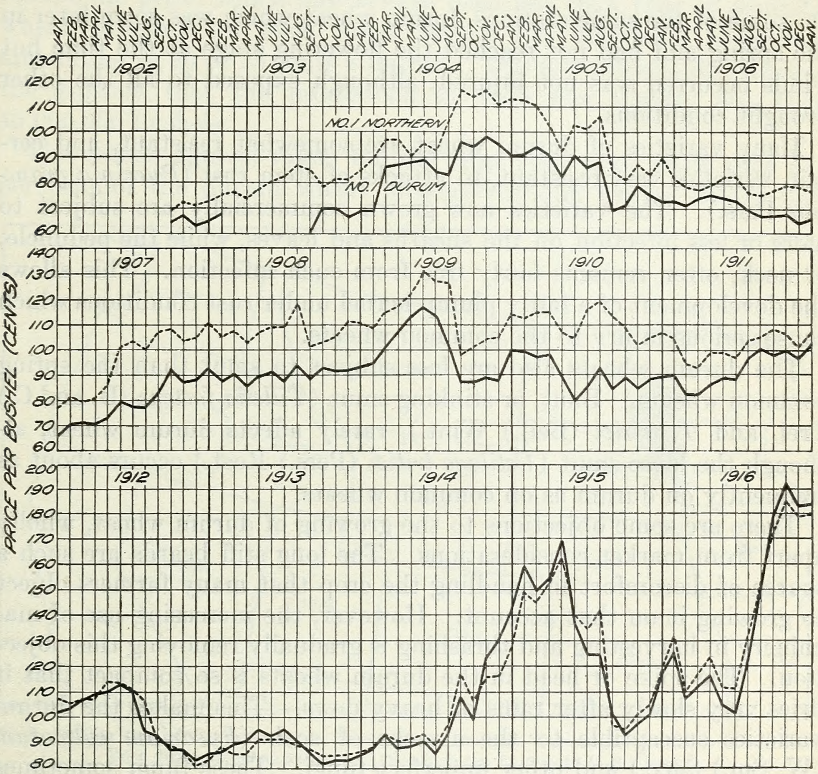

FIG. 1.—Diagram showing the prices of No. 1 Durum wheat and No. 1 Northern wheat at Duluth, Minn., on the first day of each month in the 15 years from 1902 to 1916, inclusive.

ADAPTATION.

The characters which have given the durum wheats their outstanding agricultural value are resistance to, or evasion of, drought and rust. Some of the factors involved are rapid and vigorous growth, fairly early maturity, and some measure of actual resistance to drought and the attacks of rust. Under certain climatic conditions the combination results in a uniformly higher yield than that of any varieties of common wheat.

The durum varieties certainly tolerate or withstand drought to a much greater degree than common wheats. This has given them their widespread popularity in the western half of the northern Great

Plains. An apparent exception to this high-yielding power under drought conditions was noted at several stations in the two very dry years, 1910 and 1911. In these years the durum wheats produced relatively low yields. This was found to be due, however, not to lack of drought resistance, but to sterility caused by a combination of climatic conditions, including drought and hot winds coincident with the flowering period of durum wheat. The floral organs were injured, and the kernels did not develop, much reducing the yields. On some of the same stations durum wheat which was sown later in the spring and had not reached the flowering stage at the time hot winds occurred was not injured, although exposed to all the other drought conditions.

Many varieties of durum wheat are somewhat resistant, and certain varieties very resistant, to attacks of stem rust (*Puccinia graminis* Pers.). The varieties now grown commercially are subject to more or less infection on the sheaths and leaves, while the peduncle, or neck, often remains fairly free from such infection. This allows the development of a fairly plump kernel under rust conditions which cause serious injury to the common wheats.

The durum wheats also are less subject to smut than the spring common wheats. Bunt, or stinking smut (*Tilletia foetens* (B. and C.) Trel. and *T. tritici* (Beij.) Wint.), rarely affects durum wheat, although the loose smut (*Ustilago tritici* (Pers.) Rost.) occurs about as frequently on durum as on common wheats.

There are some objections to the growing of durum wheat, wholly apart from market considerations. The long stiff beards are such a source of discomfort in handling the crop that many farmers object to growing it on that account. However, the increasing use of machinery in harvesting and thrashing is gradually removing this objection. The spike or head in the durum wheats is so compact that it dries very slowly after rains or heavy dews. This makes the durum varieties susceptible to the attacks of scab (*Fusarium culmorum* (W. Sm.) Sacc.) and other imperfect fungi. These fungi sometimes affect durum wheat rather seriously.

The durum wheats have come from countries of low rainfall and fairly high summer temperatures, where loss of moisture by evaporation is rapid. The results of many experiments show them to be valuable under similar conditions in the northern Great Plains in this country. On account of their ability to produce well in the presence of rust infection, they also are valuable and widely grown in the subhumid portions of the Dakotas and western Minnesota.

PRODUCTION.

The varieties of durum wheat introduced by the United States Department of Agriculture in the years 1898 to 1900 were distributed to farmers as well as to experiment stations. The new introductions soon became popular among farmers of the northern Great Plains.

Among the varieties distributed, the Kubanka and Arnautka proved to be well adapted.

Production increased rapidly during the early years. It rose from 60,000 or 70,000 bushels in 1901 to about 6,000,000 or 7,000,000 bushels in 1903, and probably about 50,000,000 bushels by 1906. As noted in the discussion of its history, the development of the market did not keep pace with the increased production. For this reason the price, which had always been less than that of common wheat, dropped to even lower levels, the difference sometimes amounting to 20 or 25 cents a bushel. This low price so discouraged the growers that the production in 1909 was slightly less than 40,000,000 bushels.

The census figures, taken for the crop year 1909, show that 87½ per cent of the durum wheat produced in the United States that year was grown in North Dakota and South Dakota. Minnesota ranked third in production, with about 7 per cent of the total crop, and practically all of the remaining 5 or 6 per cent was grown in Nebraska, Kansas, Colorado, Wyoming, and Montana. Figure 2 is an outline map of the northwestern United States, illustrating the production of durum wheat in 1909.

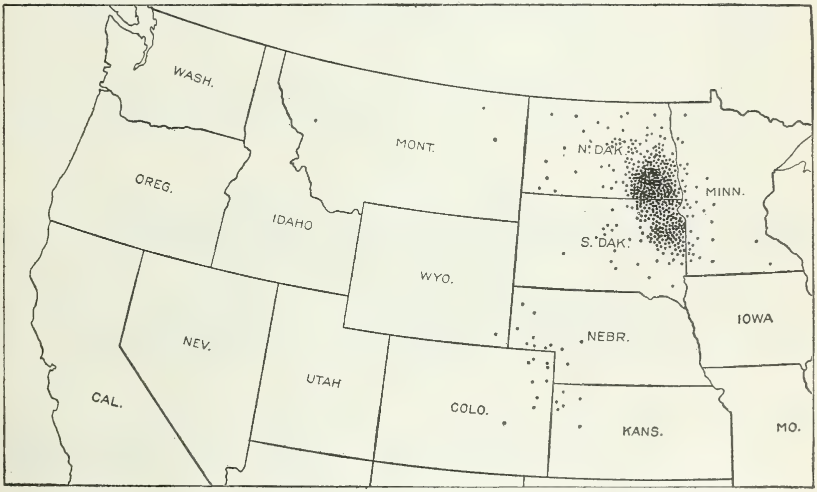

FIG. 2.—Outline map of the northwestern United States, showing the acreage of durum wheat in 1909. Each dot represents 5,000 acres. (Data from the Thirteenth U. S. Census.)

Since 1909 the Bureau of Crop Estimates of the United States Department of Agriculture has gathered annual data upon the acreage and production of durum wheat in the three States of Minnesota, North Dakota, and South Dakota. In 1915 Montana was added. Table I shows the estimated annual production of durum wheat and of all other wheats and the percentage of durum in the total wheat production in the three States named during the eight years from 1909 to 1916, inclusive.

TABLE I.—*Estimated annual production of durum and of all other wheats and the percentage of durum in the total wheat production in Minnesota, North Dakota, and South Dakota in the eight years from 1909 to 1916, inclusive.*[1]

[Production expressed in thousands of bushels (000 omitted).]

State and kind of wheat.	1909	1910	1911	1912	1913	1914	1915	1916	8-year average.
Minnesota:									
Durum wheat	2,810	2,624	1,494	2,334	1,692	990	1,400	613	1,745
Other wheat	54,284	61,376	42,441	64,704	66,348	41,985	72,020	26,942	53,763
Percentage of durum in total	4.9	4.1	3.4	3.5	2.5	2.3	1.9	2.6	3.1
North Dakota:									
Durum wheat	19,176	6,276	11,126	17,884	10,302	10,389	22.000	7,275	13,054
Other wheat	97,606	32,224	62,074	125,936	68,553	71,203	129.970	32,050	77,452
Percentage of durum in total	16.4	16.3	15.2	12.4	13.1	12.7	14.5	18.5	14.4
South Dakota:									
Durum wheat	15,845	15,231	3,404	14,343	9,535	6,724	14,500	2,999	10,323
Other wheat	31,215	31,489	11,396	37,842	24,440	24,842	49,262	21,826	29,039
Percentage of durum in total	33.7	32.6	23.0	27.5	28.1	21.3	22.8	12.1	26.2
Total of all three States:									
Durum wheat	37,831	24,131	16,024	34,561	21,529	18,103	37,900	10,887	25,121
Other wheat	183,105	125,089	115,911	228,482	159,341	138,040	251,252	80,818	160,225
Percentage of durum in total	17.1	16.2	12.1	13.1	11.9	11.6	13.1	11.9	13.6

[1] These figures are estimates made in the Bureau of Crop Estimates of the United States Department of Agriculture, except for 1909, for which year they are taken from the Thirteenth Census.

In 1909 the total production was 39,958,947 bushels. In 1910 and 1911 the production was reduced by severe drought to about 24,000,000 and 16,000,000 bushels, respectively. With a short crop and increasing demand, durum prices became about equal to those of common wheat. In 1912 the production was again increased to slightly less than 40,000,000 bushels, the price remaining equal to that

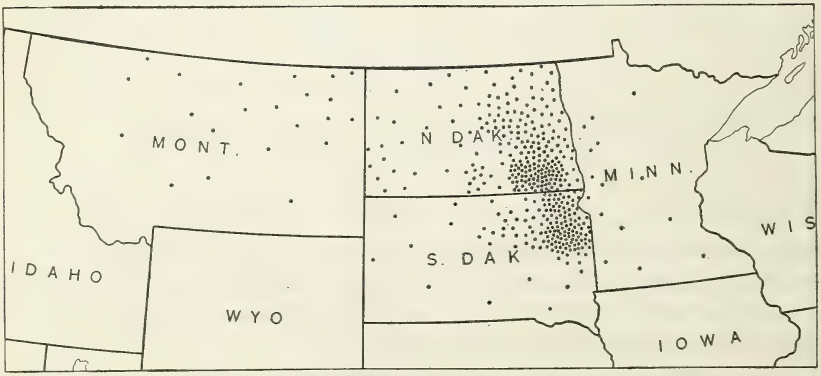

FIG. 3.—Outline map showing the acreage of durum wheat in 1915 in the States of Minnesota, North Dakota, South Dakota, and Montana. Each dot represents 5,000 acres. (Data from the Bureau of Crop Estimates, United States Department of Agriculture.)

of other wheats. Production was reduced again during the years 1913 and 1914. This smaller production was responsible in part for the higher price which was obtained for the crop during these years. In 1915 production increased sharply in response to the stimulus of good prices and increasing demand. Since the fall of 1911, as noted previously, the price of durum wheat usually has been equal to or slightly better than that obtained for common spring wheats. (See fig. 1.) Several causes have contributed to this. Among them are (1) better facilities for milling these hard wheats, (2) increasing use for making macaroni in this country, and (3) increasing export demand. Figure 3 is a map showing the production of durum wheat in Minnesota, South Dakota, North Dakota, and Montana in 1915, according to the figures of the Bureau of Crop Estimates.

DESCRIPTION AND KEY.

In the genus Triticum, durum wheat has been regarded as one of the seven or eight species or subspecies. The writers are not concerned with its taxonomic status at this time, but merely with those characters which mark the durum wheats as distinct from the common wheats.

DESCRIPTION.

Durum wheat differs from common wheat in the characters of both plant and kernel. The durum plant usually is taller (fig. 4) and more vigorous than that of common wheat varieties; the culms are thicker and the leaves broader. The spikes average broader and shorter (see fig. 9) than those of common wheat and are much more compact. In some varieties they are so short and broad as to be veritable club wheats.

The crowding of the spikelets on the rachis, together with the large size of the kernel, results in a characteristic outcurving or expansion of the spikelet which widens the spike on both sides of the rachis. As a result, the spike is flattened transversely to the plane of the rachis or to the plane of the face of the spikelets (fig. 5) instead of parallel with it, as in the case of common wheat.

The awns of durum wheat are much longer than those of any variety of common wheat. They vary in length from 1 to 2½ decimeters or more. The long, stiff awns and the compact head give the plant much the appearance of barley, for which it is often mistaken by those not familiar with the crop.

The kernels of durum wheat are larger than those of common wheat (fig. 6), varying from about 7 to 10 mm. in length, with an average length of 8 to 8½ mm. As the name indicates, the kernels are very hard, the endosperm being entirely corneous. The seed coats are unpigmented. The effect of the completely corneous endosperm and unpigmented seed coats is a kernel of a clear amber appearance,

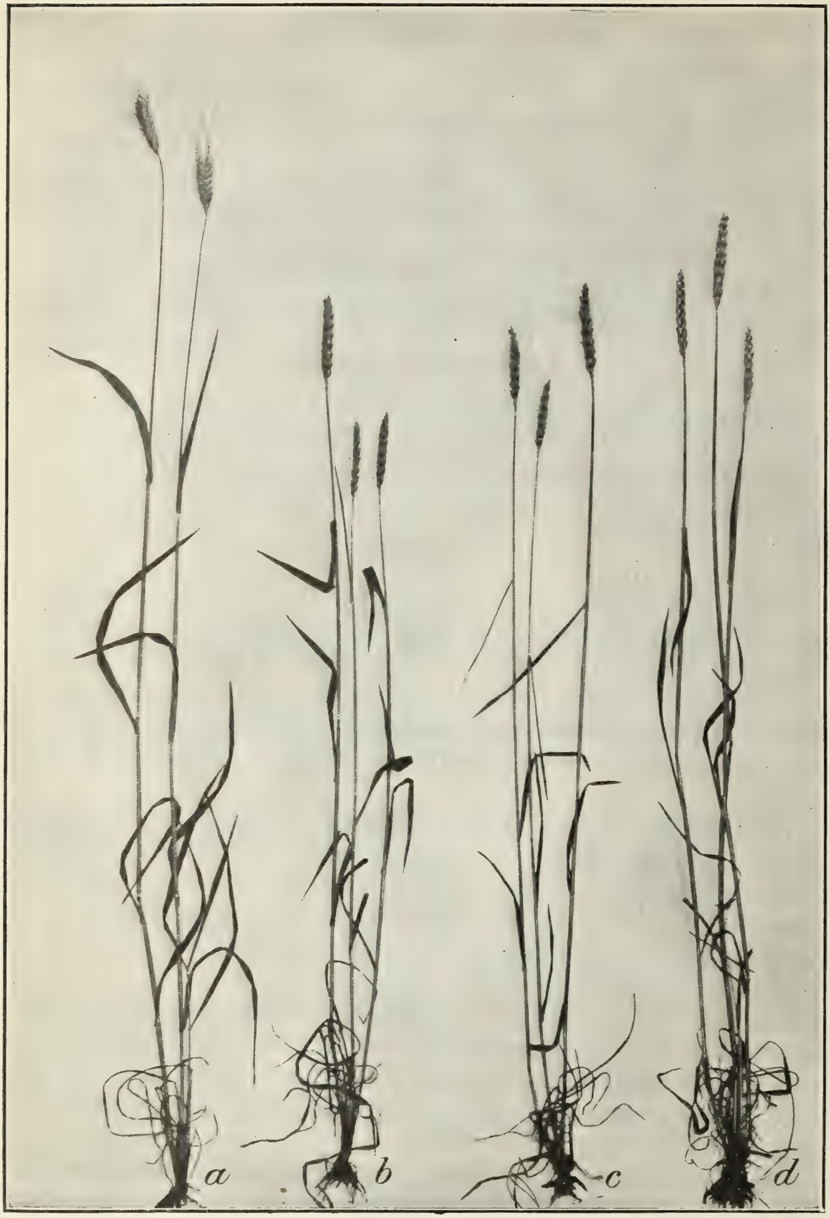

FIG. 4.—Plants of four hard spring wheats, representing durum wheat and three groups of common wheat: *a*, Kubanka (durum); *b*, Fife (Rysting); *c*, Preston; *d*, Bluestem (Haynes).

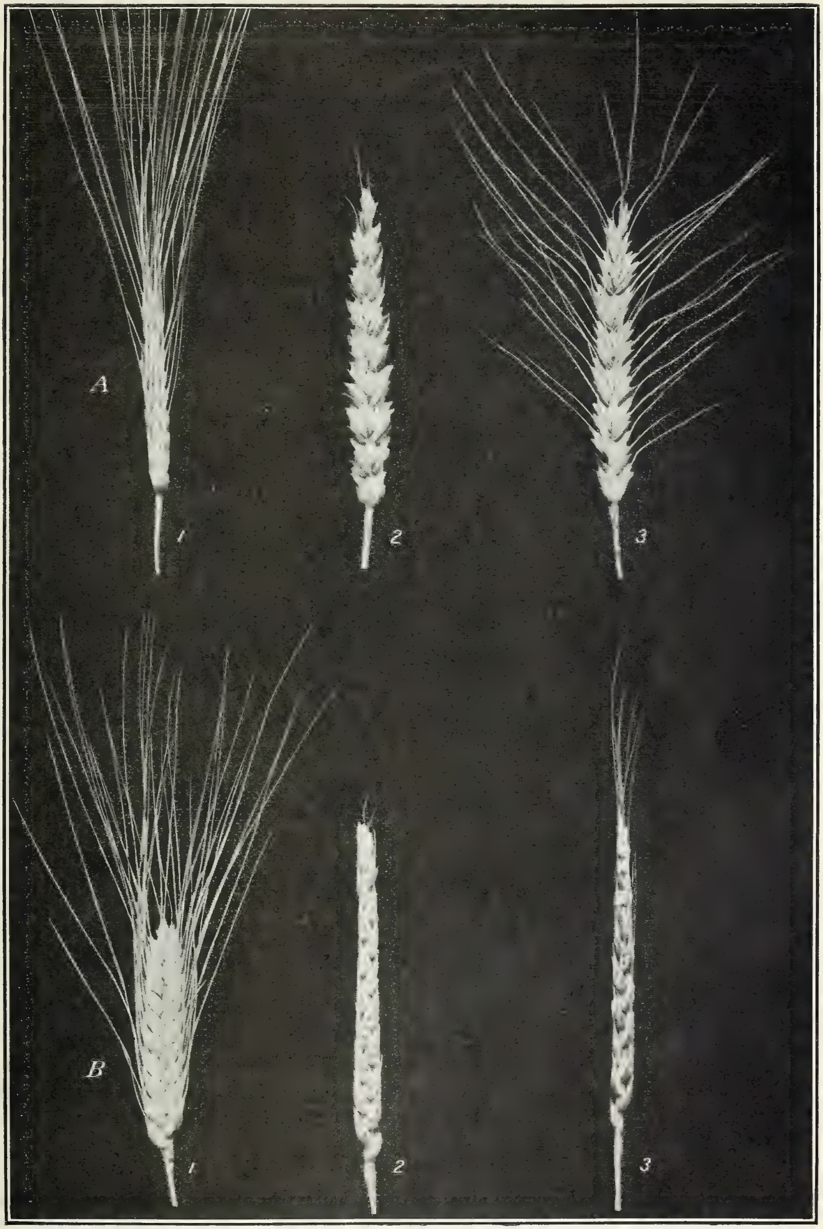

FIG. 5.—Heads of durum and common wheat in two positions: *A*, Face view of spikelets; *B*, edge view of spikelets. 1, Kubanka (durum); 2, Bluestem; 3, Preston.

somewhat translucent or vitreous. Some varieties of durum wheat have red kernels. Only one of these, D5,[1] has become commercially grown in the United States, and this at so recent a date that it is not discussed elsewhere in this bulletin.

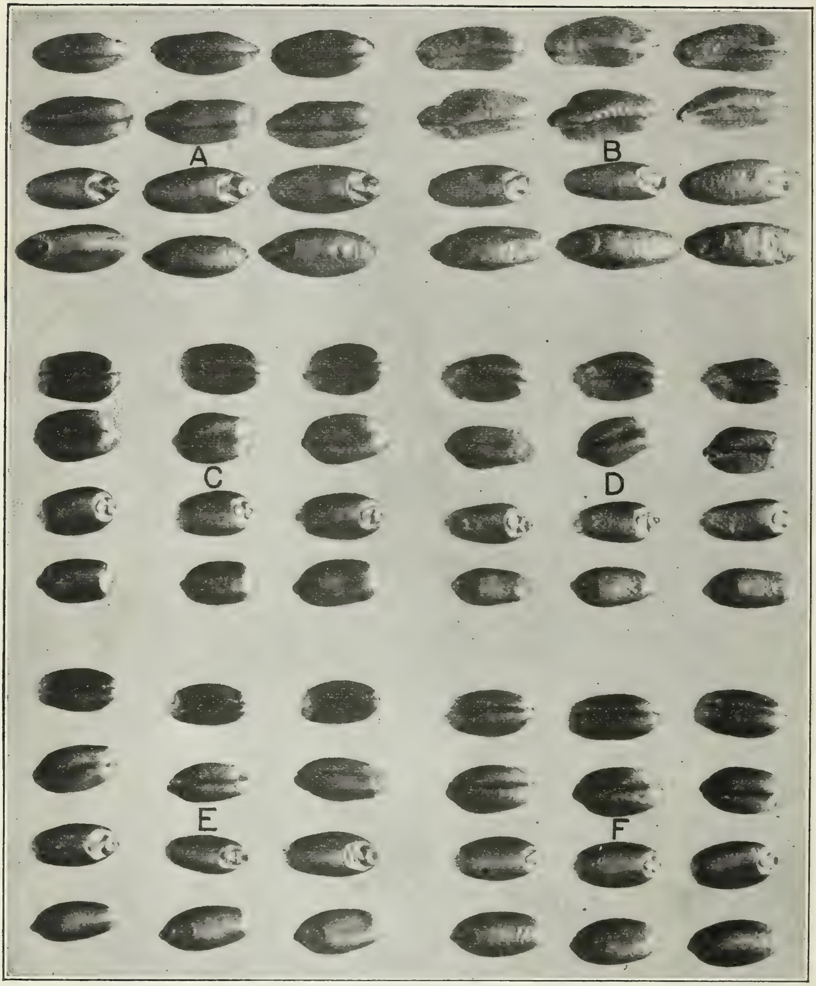

FIG. 6.—Kernels of two varieties of durum wheat and four varieties of common wheat, each variety representing a different group: *A*, Kubanka; *B*, Pelissier; *C*, Marquis (Fife); *D*, Haynes (Bluestem); *E*, Preston; *F*, Turkey (Crimean).

KEY TO GROUPS AND VARIETIES.

Below is given a key to the groups and varieties of durum wheat discussed in this bulletin. Heads of varieties representing the four chief groups are shown in figure 7.

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[1] This variety originated from a selection made by Prof. H. L. Bolley, of the North Dakota Agricultural Experiment Station, in a field of durum wheat in Russia. It was tested, increased, and distributed by him as D5. It is an exceptionally rust-resistant variety, but of poor bread-making quality. This is the red durum on which is based the subclass "Red Durum" of the United States Grain Standards Act. (Houston, 1917.)

Key to the groups and varieties of durum wheat.

Group.

Spike awned, flattened transversely to the plane of the rachis; kernel white (amber), vitreous (hard).
 Glumes glabrous.
  Glumes white to light brown.
   Awns white to light brown .... *Kubanka.*
    Spike oblong to broadly oblong.
     Beaks 1–2 mm. long.
      Plant tall. (Argentine, Beloturka, Buford, Gharnovka, Kubanka, Pererodka, Taganrog, Yellow Gharnovka.)
      Plant midtall; spike narrower. (Monad.)
     Beaks 1–10 mm. long. (Marouani, Saragolla.[1])
    Spike narrowly oblong, strongly nodding, beaks 1–3–5 mm. long. (Arnautka.)
   Awns black .... *Pelissier.*
    Beaks 1–2 mm. long. (Medeah.)
    Beaks 1–10 mm. long. (Pelissier.)
 Glumes thinly to densely pubescent.
  Glumes white. (Velvet Don.) .... *Velvet Don.*
  Glumes brown to black, beak 1–2 mm. long. (Black Don, Kahla, Purple.) .... *Kahla.*

VARIETAL EXPERIMENTS.

This bulletin is believed to contain the results of all the important varietal experiments with durum wheats which have been conducted in the United States. The results of two experiments in Canada are included also. As early as 1892 the North Dakota Agricultural Experiment Station had a durum variety (Wild Goose) in its varietal experiments, and in 1893 it was included by the South Dakota Agricultural Experiment Station also. Experiments with durum wheat were begun in 1895 by the Canadian Department of Agriculture. From 1899 to 1903 stations in a number of different States began experiments with a series of durum wheat varieties.

The seed of the varieties tested by the Canadian stations was obtained by them. The varieties under experiment by the various stations in the United States were mostly those introduced by the United States Department of Agriculture from Russia and elsewhere, and the accession numbers they bear in the tabulated data are those of the Office of Cereal Investigations.

Geographic Scope.

Seventeen different States and Provinces are covered by the varietal experiments presented in this bulletin. They extend from Iowa and Wisconsin on the east to California and Oregon on the west, and from Texas on the south to Manitoba and Saskatchewan on the north. All the intervening States are included except Oklahoma, New Mexico, Arizona, and Washington.

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[1] A black-awned strain also is grown.

The adaptation and value of durum wheat vary with the environment. There is naturally a wide variation in soil and climate within this great expanse of territory. The eastern portion is distinctly humid, and the soil consists of glacial drift and alluvium. Farther west, in the Great Plains area, the precipitation decreases, the altitude increases, and the growing season becomes shorter. The soils are mostly heavy clay loams, varying to heavy clays or gumbo on the one hand and to sandy loams and sands on the other.

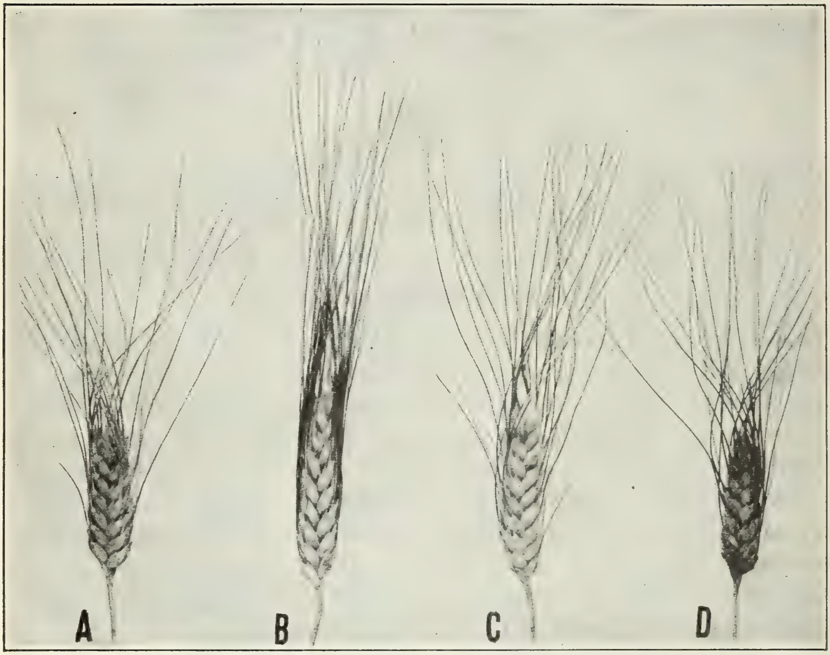

FIG. 7.—Heads of four different groups of durum wheat. *A*, Kubanka; *B*, Pelissier; *C*, Velvet Don; *D*, Kahla. (About half natural size.)

West of the Rocky Mountains new sets of conditions present themselves. The precipitation usually is low, and sometimes very low. The altitude in the great interior basins is high, except in the Columbia Basin, where it seldom exceeds 2,000 feet. In the California valleys the altitude is low. The soils throughout are mostly light in texture.

For convenience in presenting and interpreting results the territory under discussion is separated into three different divisions, according to the environmental conditions. These three divisions are called (1) the Prairie States, or subhumid area; (2) the Great Plains, or semiarid area; (3) the basin and coast or arid area, including the Salt Lake Basin, Snake River Basin, Humboldt Basin, Harney Valley, Columbia Basin, and the California valleys.

The locations of the stations, together with their altitude above sea level, are shown in Table II. The normal or average rainfall, in inches, with the number of years on which such average is based, also is given. The United States Weather Bureau establishes normals for their independent stations on 33-year records. At all other points the rainfall recorded is the average for the years during which observations have been made. Finally, the table shows the general soil type on which each station is located.

TABLE II.—*Altitude, normal and average precipitation, and soil type at 30 experiment stations at which experiments with durum wheat have been conducted.*

Area and station.	Altitude.	Precipitation.		Type of soil.
		Normal or average.	Length of record.	
	Feet.	*Inches.*	*Years.*	
Prairie (subhumid) area:				
McPherson, Kans	1,495	31.22	26	Deep sandy loam.
Manhattan, Kans	1,014	32.59	56	Dark-brown silt loam.
Lincoln, Nebr	1,189	27.51	33	Alluvial clay loam.
Ames, Iowa	922	32.64	40	Black silt loam.
Brookings, S. Dak	1,636	20.51	27	Glacial sandy loam.
Ashland, Wis	615	28.43	16	Red clay.
St. Paul, Minn	837	28.68	33	Light clay loam.
Crookston, Minn	863	21.76	26	Heavy clay loam.
Fargo, N. Dak.[a]	935	24.92	33	Heavy black clay loam.
Great Plains (semiarid) area:				
Amarillo, Tex	3,676	21.21	24	Chocolate clay loam.
Hays, Kans	2,000	23.16	48	Silty clay loam.
Akron, Colo	4,560	19.72	11	Sandy loam.
North Platte, Nebr	3,000	18.86	33	Loess.
Archer, Wyo.[b]	6,027	14.23	33	Medium sandy loam with some gravel.
Highmore, S. Dak	1,890	16.75	22	Glacial clay loam.
Eureka, S. Dak	1,884	16.43	7	Glacial sandy loam, stony portion of old moraine.
Newell, S. Dak	2,900	14.06	8	Clay (gumbo), shale subsoil.
Edgeley, N. Dak	1,468	18.05	15	Light sandy loam, shale subsoil.
Langdon, N. Dak	1,615	17.88	4	Black clay loam.
Dickinson, N. Dak	2,453	15.70	24	Sandy loam to clay loam.
Williston, N. Dak	1,875	14.90	33	Fine sandy loam.
Moccasin, Mont	4,228	16.66	18	Dark clay loam, gravelly subsoil.
Brandon, Manitoba	1,176	12.95	9	Sandy loam.
Indian Head, Saskatchewan	1,924	19.44	10	Light sandy to heavy loam, with clay subsoil.
Western basin and coast (arid) area:				
Nephi, Utah	6,000	13.48	17	Sandy clay loam.
Aberdeen, Idaho	4,400	9.46	4	Lava ash (sandy clay loam).
Burns, Oreg	4,100	11.74	12	Silt loam to a very fine sandy loam.
Moro, Oreg	1,800	11.35	11	Silt loam.
Chico, Cal	189	23.59	45	Sandy loam.
Modesto, Cal	90	10.52	44	Do.

[a] Observations made at Moorhead, Minn.

[b] Observations made at Cheyenne, Wyo.

The stations listed in Table II are grouped in the three geographic divisions named. It will be noted that there is no sharp line of demarcation between the different divisions, either in rainfall, elevation, or soil type. For example, Amarillo, Tex., and Hays, Kans., located in the semiarid area, have a higher annual rainfall than Brookings, S. Dak., which is considered in the subhumid area. Not only is the rainfall at Amarillo higher than that of Brookings, but it is also higher than that of Crookston, Minn., and is slightly below that of

Fargo, N. Dak. The evaporation, however, is much higher at Amarillo than at these stations in the northern part of the subhumid division of the Great Plains area.

Results Obtained.

The results of varietal experiments with durum wheat at 30 different experiment stations are presented herein. At most of these stations the experiments have been conducted by the Office of Cereal Investigations, either cooperatively with the State experiment station or some other agency or independently. At the remaining stations the data have been obtained independently by the State or Province. The source of the data is stated in connection with each station.

The experimental conditions, such as crop sequence, size of plat, width of alleys, number of replications, etc., vary somewhat at different stations. The results obtained at one station, therefore, are not necessarily comparable with those obtained at any other station. In most cases, however, they probably are directly comparable. The results from different varieties at the same station were nearly always obtained under similar conditions and may be compared directly. Any known exceptions to this fact are stated in the text. In all cases the crops are grown with only the natural rainfall and under conditions approximating good farm practice for the district.

The value to crops of any given rainfall depends on the time and nature of its occurrence, on the kind of soil, and on the quantity and nature of the wind, as well as on other factors. Not one factor, but the total influence of all factors, must govern the classification of land for agricultural purposes.

The results from the durum varieties under experiment are shown for each station. Usually all varieties that have been grown for more than one or two years are included. In the tables they are separated into the major groups given in the key to groups and varieties.

The yields of the durum wheats are compared with those of the standard common wheats at each station. The highest yielding variety in each important group of common wheat is chosen for this comparison. Occasionally two varieties are given in one group, as in the Fife group, where such old standard varieties as Power, Glyndon, and Rysting are now being outyielded by Marquis.

In figures 8, 12, and 13, the vertical column showing the yield of durum wheat is based on the yield of only the highest yielding variety in the period of years indicated, except when otherwise noted.

RESULTS IN THE SUBHUMID PRAIRIE SECTION.

The prairie section (fig. 8) includes the stations in Wisconsin, Minnesota, Iowa, eastern Kansas and Nebraska, and extreme eastern North and South Dakota. Nine stations which have experimented with durum wheat are located in this section. The names of these stations, their altitude, normal or average annual rainfall for a period of years, and the general soil type on which they are located have already been given in Table II.

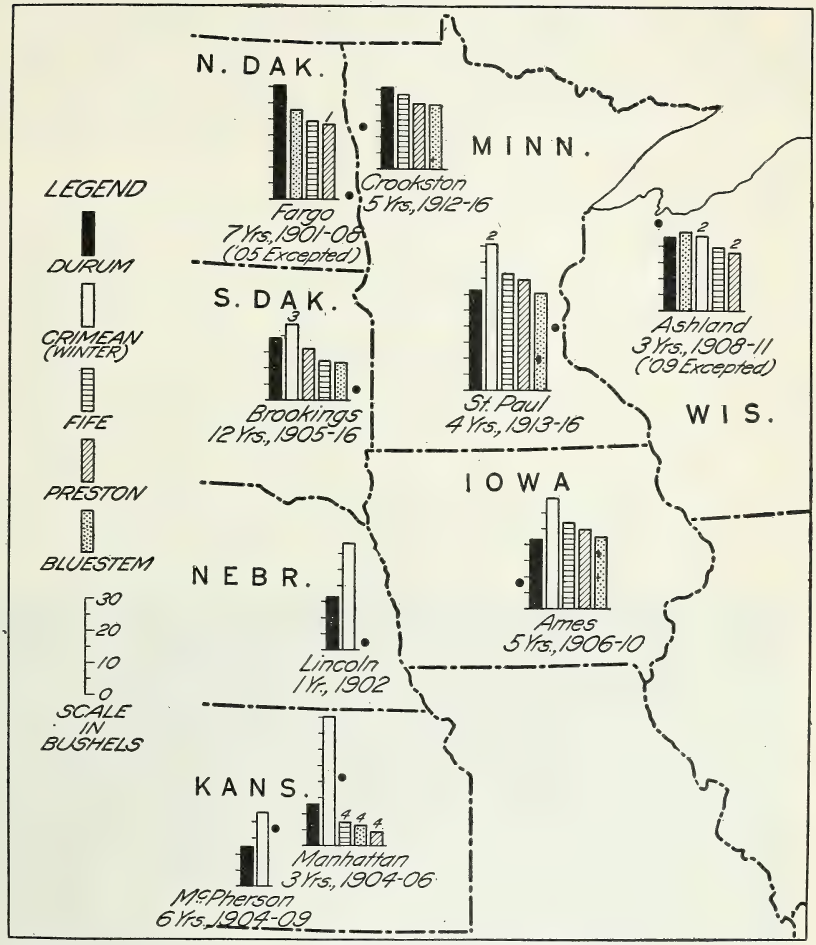

FIG. 8.—Diagram showing the location of nine stations in the Prairie States and the average yield of the leading variety of durum and the leading variety of each of several different groups of common wheat at each station during the periods of years indicated: 1, Average of only four years (Preston at Fargo); 2, average of only three years (Crimean at St. Paul and Crimean and Preston at Ashland); 3, average of only ten years (Crimean at Brookings); 4, average of only two years (Fife, Bluestem, and Preston at Manhattan).

Experiments with durum wheat have been conducted at some other stations adjacent to the subhumid section on the east and also at stations in some of the Eastern and Southern States. These tests have all been of short duration. The principal ones were conducted at Madison, Wis.; DeKalb, Ill.; Arlington Farm, at Rosslyn, Va.; Statesville, N. C.; and Athens, Ashburn, and Quitman, Ga. At Madison, Wis., and De Kalb, Ill., durum varieties were found not adapted and were discarded because of poor quality of grain or low yields. At the stations in the Eastern and Southern States the durum varieties were grown with the winter wheats adapted to those sections. Fair yields were obtained from durum varieties when fall sown, but all were low in comparison with the yields of the common wheats.

In general, the altitude in the Prairie States increases and the precipitation decreases from east to west. The altitude varies from 600 to 1,600 feet, in round numbers. The average annual rainfall at these stations varies from 32.6 to 20.5 inches. The three stations having the lowest rainfall are located in the valleys of the Sioux and Red Rivers near the Minnesota-Dakota boundary. Properly speaking, these valleys are the only portions of this section that can be called subhumid. Most of the remainder would be better designated as humid, although the eastern portions of Nebraska and Kansas might easily be placed as either subhumid or humid territory.

The annual rainfall usually is sufficient for normal crop production. Nearly half of it falls during the four summer months, from May to August, inclusive. The growing season is fairly long, varying from about 130 to more than 150 days.

Figure 8 shows, by means of graduated columns, the average yield of the best durum-wheat variety and of the leading variety in each of several groups of common wheat in varying periods of years at the nine stations. The same data will be found in tabulated form in Tables III to XI, inclusive.

Figure 9 shows heads of five varieties of wheat, one durum and four common, each representative of a group important in the prairie section and in the Great Plains area.

RESULTS AT M'PHERSON, KANS.

As shown in Table II (page 15), McPherson is located on a deep sandy loam at an altitude of almost 1,500 feet. The average precipitation has been 31.2 inches in a 26-year period. The experiments at McPherson were conducted in cooperation with the Kansas Agricultural Experiment Station. The results are shown in Table III and graphically in figure 8.

Durum varieties were under experiment for six years, though in one year, 1908, the records of the yields of all varieties but one were lost. Since McPherson is located outside of the spring-wheat belt, no spring varieties of common wheat were grown. Hard red winter wheats of the Crimean group, such as Crimean, Kharkof, and Turkey, are the standard varieties in that district. The durum varieties are compared, therefore, with Kharkof (C. I. No. 1442), one of the best yielders in the Crimean group.

TABLE III.—*Annual and average yields of five varieties of durum wheat and one variety of common wheat grown at the McPherson (Kans.) substation during periods of varying length in the six years from 1904 to 1909, inclusive.*

[Data obtained in cooperation with the Kansas Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.[a]	Yield per acre (bushels).							
		1904	1905	1906	1907	1908	1909	Average.	
								5 years, 1904–1907 and 1909.	6 years, 1904 to 1909.
Durum:									
Kubanka—									
Kubanka	2246	16.3	14.2	24.0	0	(b)	13.8	13.7	....
Do.	2094	12.7	11.3	25.6	0	13.5	12.6	12.4	12.6
Kahla—Black Don	2100	11.7	14.5	24.5	0	(b)	13.4	12.8	....
Pelissier—									
Pelissier	2086	11.0	11.7	21.7	0	(b)	11.6	11.2	....
Saragolla	2228	10.3	9.8	16.7	0	(b)	10.9	9.5	....
Common:									
Crimean (winter)—Kharkof	1442	25.9	18.4	35.1	20.9	19.5	19.5	24.0	23.2

[a] Cereal Investigations number.

[b] Record of yields lost.

Reference to Table III and figure 8 shows that the Kharkof winter wheat outyields the best durum variety in the ratio of nearly 2 to 1. Among the durum varieties a Kubanka leads. Since this district is not suited to the growing of spring-sown varieties of wheat, it is not surprising that the Crimean wheat so far surpasses the durum. In 1906, however, the yields of the durum varieties ranged from 16.7

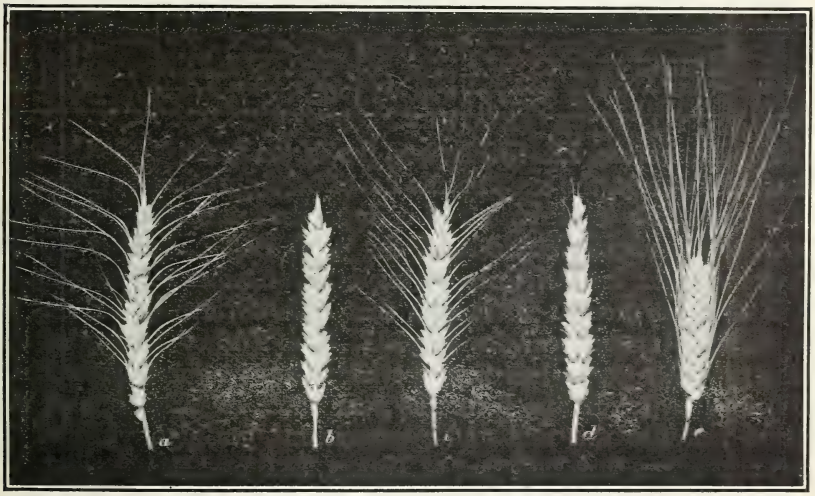

FIG. 9.—Heads of representative varieties of five groups of wheat: *a*, Turkey, a hard red winter wheat; *b*, Fife; *c*, Preston; *d*, Bluestem; *e*, Kubanka (durum; edge view).

to 25.6 bushels, while the 5-year average yields of four varieties ranged from 11.2 to 13.7 bushels. This shows that in the event of great damage to the winter-wheat crop in autumn or winter the loss might be retrieved in a large measure by sowing durum wheat the following spring.

RESULTS AT MANHATTAN, KANS.

Manhattan is located, according to Table II (p. 15), on a dark-brown silt-loam soil at an altitude of 1,014 feet. The normal annual rainfall, based on a 56-year record, is 32.6 inches. The experiments were conducted independently by the Kansas Agricultural Experiment Station, and the results are copied from Bulletin 144 (Ten Eyck and Shoesmith, 1907) of that station. The results are shown in full in Table IV and graphically in figure 8.

TABLE IV.—*Annual and average yields of two varieties of durum wheat and four varieties of common wheat grown at the Kansas Agricultural Experiment Station, Manhattan, Kans., during periods of varying length in the four years from 1903 to 1906, inclusive.*

Class, group, and variety.	Yield per acre (bushels).					
	1903	1904	1905	1906	Average.	
					2 years, 1903 and 1904.	3 years, 1904 to 1906.
Durum:						
Kubanka—Gharnovka	13.3	11.1	....	....	12.2	....
Velvet Don—Velvet Don	12.0	7.0	18.0	12.8	9.5	12.6
Common:						
Crimean—Turkey (No. 4)	....	34.9	38.6	46.9	....	40.1
Fife—Glyndon	9.6	5.3	....	....	7.5	....
Bluestem—Haynes	7.0	6.1	....	....	6.6	....
Preston—Preston	7.0	1.9	....	....	4.5	....

Since Manhattan, like McPherson, lies in the heart of the Crimean winter-wheat belt, the experiments are of brief duration, as not much could reasonably be expected of spring-wheat varieties. Table IV shows the comparative yields in the years 1903 and 1904 of two durum varieties and of three spring common wheats belonging to three different groups. It is seen that both durums exceed any of the spring common varieties in yield. The Turkey variety of the Crimean winter group, however, outyields the best durum grown in a ratio of 3 to 1. In the favorable year 1905, in which one of the durum varieties was still under experiment, its high yield of 18 bushels was less than half that of Turkey, 38.6 bushels per acre.

RESULTS AT LINCOLN, NEBR.

The Nebraska Agricultural Experiment Station is located on an alluvial clay-loam soil at an altitude of 1,189 feet above sea level. The normal precipitation is 27.5 inches. The experiments at Lincoln were conducted independently by the Nebraska Agricultural Experiment Station, and the data given in Table V are taken from publications of that station (Lyon, 1903; Lyon and Keyser, 1905). The principal data are shown also graphically in figure 8.

TABLE V.—*Yields of seven varieties of durum wheat and three varieties of common wheat grown at the Nebraska Agricultural Experiment Station, Lincoln, Nebr., in 1902.*

Class, group, and variety.	Yield per acre (bushels).	Class, group, and variety.	Yield per acre (bushels).
Durum:		Durum—Continued.	
Kubanka—		Kahla—Kahla	7.3
Gharnovka	16.5		
Yellow Gharnovka	14.5	Common:	
Pererodka	14.0	Crimean (winter)—	
Kubanka	12.5	Turkey	33.2
Velvet Don—Velvet Don	10.5	Crimean	29.2
Pelissier—Pelissier	7.5	Kharkof	22.3

As shown in Table V, the durum wheats were tested at Lincoln in but a single year, 1902. Lincoln lies in the heart of the hard winter-wheat belt, and spring-sown wheat can not compete with the varieties of the Crimean group. The average yield of the seven durum varieties is only 11.8 bushels, whereas the average yield of the three Crimean varieties is 26.2 bushels per acre. The yield of the best durum, Gharnovka, in the Kubanka group, is 16.5 bushels, whereas the yield of the best Crimean, Turkey, is 33.2 bushels per acre, or exactly double the yield of the Gharnovka. On the basis of known facts, there was no economic reason for continuing further a varietal experiment with durum wheat at Lincoln.

RESULTS AT AMES, IOWA.

Ames, Iowa, as seen from Table II, is located on the Marshall silt-loam soil at an altitude of 922 feet. The average annual rainfall for a 40-year period is 32.6 inches. The experiments cited were conducted cooperatively by the Iowa Agricultural Experiment Station and the Office of Cereal Investigations.

Experiments including durum wheat cover the 5-year period from 1906 to 1910, inclusive. The results are given in Table VI, and the principal ones are shown graphically in figure 8.

Among the durums only Kubanka was tried, and the results are unfavorable when compared with those from the other varieties. None of the spring wheats does well, but all three of the spring common varieties are better than Kubanka. As might be expected in central Iowa, winter wheat is much more productive than any spring wheat. The 5-year average yield of Turkey, of the Crimean group, is nearly 10 bushels higher than that of the best spring common wheat. Durum wheats have no place in so humid a climate as that of central Iowa.

TABLE VI.—*Annual and average yields of one variety of durum wheat and four varieties of common wheat grown at the Iowa Agricultural Experiment Station, Ames, Iowa, during periods of varying length in the five years from 1906 to 1910, inclusive.*

[Data obtained in cooperation with the Iowa Agricultural Experiment Station.]

Class, group, and variety.	Yield per acre (bushels).						
	1906	1907	1908	1909	1910	Average.	
						3 years, 1908 to 1910.	5 years, 1906 to 1910.
Durum:							
Kubanka—Kubanka	21.4	22.5	14.3	14.5	34.5	21.1	21.5
Common:							
Crimean (winter)—Turkey	39.7	37.4	37.6	27.7	30.0	31.8	34.5
Preston—Early Java	25.1	20.5	15.7	26.5	36.7	26.3	24.9
Fife—Glyndon (Minn. No. 163)	....	....	17.2	21.3	41.6	26.7	....
Bluestem—Haynes (Minn. No. 169)	24.1	19.6	8.7	23.0	38.3	23.3	22.7

RESULTS AT BROOKINGS, S. DAK.

According to Table II (p. 15), Brookings is situated on a glacial sandy loam at an altitude of 1,636 feet, the greatest elevation of any station in the prairie section. The average rainfall, based on a 27-year period, is 20.5 inches. The experiments were conducted cooperatively by the South Dakota Agricultural Experiment Station and the Office of Cereal Investigations.

The experiments were begun in 1904 and have continued until the present time. Results during periods of varying length in the 13 years from 1904 to 1916, inclusive, are shown in Table VII and graphically in figure 8.

Brookings lies in the hard spring-wheat belt, and the durum wheats should be adapted to the conditions of that locality, though the rainfall is a little too high for the development of the highest quality. The annual and average yields of five varieties, two durums and three representative common wheats, are recorded for a 12-year period. The two durums, Arnautka and Kubanka, both in the Kubanka group, excel all three common wheats. One of the durums, Arnautka, outyields the common varieties by a significant average yield of 3.5 bushels per acre. Among the common wheats, Preston outyields Fife and Bluestem by 3.5 and 4.1 bushels, respectively. The Marquis variety was grown only during the last four years of the experiment. In those years, however, it outyielded all other varieties of common and durum wheat. The yields of winter wheat of the Crimean group have not been obtained consecutively throughout this period. In the 10 years, however, in which it was grown it has exceeded the Arnautka in yield by an average of 1.8 bushels.

Eight varieties of durum wheat, all in the Kubanka group, have been tested for periods of 5, 9, or 12 years. The Arnautka variety has proved best adapted, outyielding the Kubanka in each of the three periods of years mentioned. During the last five years of the test, however, the Kubanka has the advantage.

The results show that durum wheats of the Kubanka group are profitable varieties for the Big Sioux Valley. They have outyielded all spring common wheats except Marquis.

TABLE VII.—*Annual and average yields of eight varieties of durum wheat and five varieties of common wheat grown at the South Dakota Agricultural Experiment Station, Brookings, S. Dak., during periods of varying length in the thirteen years from 1904 to 1916, inclusive.*

[Data obtained in cooperation with the South Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).															
															Average.		
		1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	5 years, 1904 to 1908.	9 years, 1904 to 1912.	12 years, 1905 to 1916.
Durum:																	
Kubanka—																	
Arnautka.	1494	26.0	25.0	35.8	20.8	25.8	16.5	12.0	4.0	26.1	25.8	11.2	22.5	[a]11.1	26.7	21.3	19.7
Do.	1493	23.5	25.0	36.4	17.5	23.1	17.3	11.0	0	31.0	...	...	...	...	25.1	20.5	...
Kubanka..	1440	18.8	16.3	28.6	14.5	16.1	11.8	12.7	1.2	28.0	28.3	15.0	17.0	11.6	18.9	16.4	16.8
Do.	1541	18.6	16.5	30.4	12.7	15.8	18.0	9.2	3.8	21.6	...	...	...	...	18.8	16.3	...
Do.	1516	19.3	20.8	30.3	6.2	12.8	15.7	5.5	2.8	28.6	...	...	...	...	17.9	15.8	...
Do.	1354	21.0	18.8	38.5	15.6	16.0	...	...	...	...	...	...	...	...	22.0	...	...
Gharnovka	1546	16.1	22.2	32.5	13.8	20.1	...	...	...	...	...	...	...	...	20.9	...	...
Kubanka..	1490	22.5	18.5	28.4	11.1	12.6	...	...	...	...	...	...	...	...	18.6	...	...
Common:																	
Preston—Preston..........	3081	...	18.3	22.3	10.9	15.0	21.8	19.0	2.8	18.5	27.6	12.7	18.3	7.5	...	...	16.2
Fife—																	
Marquis...	3641	...	...	...	...	...	...	...	...	...	29.3	15.8	26.7	7.2	...	...	...
Rysting...	3022	...	15.8	23.4	7.3	14.9	15.5	16.9	3.0	16.8	20.0	[b]9.2	[b]7.5	[b]2.6	...	...	12.7
Bluestem—																	
Haynes......	2874	...	16.3	21.8	8.4	11.6	16.9	15.7	2.8	[c]15.8	[c]20.2	2.5	12.5	.6	...	...	12.1
Crimean (winter)—Turkey	3055	21.0	22.0	8.0	9.4	(d)	14.4	(d)	(d)	29.3	34.2	30.8	43.3	26.1	...	...	...

[a] Not grown; yield of Arnautka (C. I. No. 4064), a pure line selection from C. I. No. 1494, substituted.

[b] Not grown; yield of Glyndon (C. I. No. 2873) substituted.

[c] Not grown; yield of Haynes (Minn. No. 185) substituted.

[d] Winter wheats not grown.

RESULTS AT ASHLAND, WIS.

Ashland, as seen in Table II (p. 15), lies on the Superior red clay at the low altitude of 615 feet above sea level. The average annual rainfall is 28.4 inches in a 16-year period. The experiments presented in Table VIII and shown graphically in figure 8 were conducted by the Wisconsin Agricultural Experiment Station. The data have been taken from Bulletin 233 of that station (Delwiche and Leith, 1913).

The experiments continued during the four years from 1908 to 1911, inclusive. The yields of one durum, Kubanka, and three common varieties, representing three leading groups of hard spring common wheat, are presented. One winter wheat, Kharkof, of the Crimean group, also was grown. Since Ashland is near the northern edge of the winter-wheat belt, it is not surprising that the Kharkof does not excel all the spring varieties.

Kubanka durum excels Preston and Fife by yields that are fairly significant. It nearly ties with Kharkof for second place, but is outyielded by Bluestem to a degree that is fairly significant. Whether it would pay to grow a durum variety under these conditions would depend in part upon the average quality of the grain of the different varieties and in part on the frequency of rust attack.

TABLE VIII.—*Annual and average yields of one variety of durum wheat and four varieties of common wheat grown at the Ashland (Wis.) branch station during periods of varying length in the four years from 1908 to 1911, inclusive.*

Class, group, and variety.	Yield per acre (bushels).					
	1908	1909	1910	1911	Average.	
					3 years, 1908, 1910, and 1911.	4 years, 1908 to 1911.
Durum:						
Kubanka—Kubanka	22.1	22.0	26.0	22.1	23.4	23.0
Common:						
Bluestem—Haynes (Minn. No. 169)	27.7	18.2	27.3	26.4	27.1	24.9
Crimean (winter)—Kharkof	15.0	(a)	22.8	33.0	23.6	....
Fife—Glyndon (Minn. No. 163)	18.7	16.8	26.0	18.8	21.2	20.0
Preston—"Selected Bearded"	17.0	....	20.7	17.0	18.2	....

[a] Excessive rainfall (more than 12 inches in 3 days) in July, 1909, so affected the yields of winter wheat that they were not considered of value for comparative purposes.

RESULTS AT ST. PAUL, MINN.

The Agricultural Experiment Station at University Farm, St. Paul, Minn., is situated in a light sandy loam soil at an altitude of 837 feet. The normal annual rainfall is 28.7 inches. The experiments have been conducted independently by the Minnesota Agricultural Experiment Station, and the results are presented here by the courtesy of the director and his associates.

The yields presented include those of five varieties of wheat, namely, Kubanka durum and a leading representative each of the Crimean group of hard red winter wheats and the Fife, Preston, and Bluestem groups of hard spring wheat. The data are given in Table IX and are shown graphically in figure 8.

It will be noted that in the 3-year period, 1914 to 1916, inclusive, the Turkey winter wheat outyields all the others by 11 to 15 bushels per acre. Marquis, in the Fife group, outyields all the other spring wheats by about 1 bushel per acre, Kubanka durum standing second. In 1913 the Turkey wheat was not grown, while the yield of Kubanka was comparatively low. In the four years from 1913 to 1916, inclusive, the Kubanka is outyielded by Marquis, Glyndon, and Preston in quantities that are significant, while it outyields Haynes by only 0.7 bushel.

From the showing made in these years the growing of durum wheats in the vicinity of St. Paul would be justified only by their superior rust resistance in comparison with common wheats.

Table IX.—*Annual and average yields of one variety of durum wheat and five varieties of common wheat grown at the Minnesota Agricultural Experiment Station, University Farm, St. Paul, Minn., during periods of varying length in the four years from 1913 to 1916, inclusive.*

[Data presented by courtesy of the Minnesota Agricultural Experiment Station.]

Class, group, and variety.	Minn. No.	Yield per acre (bushels).					
		1913	1914	1915	1916	Average. 3 years, 1914 to 1916.	Average. 4 years, 1913 to 1916.
Durum:							
Kubanka—Kubanka	990	25.7	30.3	46.7	23.8	33.6	31.6
Common:							
Crimean (winter)—Turkey	845	....	47.8	57.0	33.3	46.0	....
Fife:							
Marquis	1239	41.9	27.7	50.0	26.3	34.7	36.5
Glyndon	285	38.6	27.0	49.2	23.2	33.1	34.5
Preston—Preston	924	43.5	26.5	46.7	22.7	32.0	34.9
Bluestem—Haynes	169	33.8	26.7	39.9	23.3	30.0	30.9

RESULTS AT CROOKSTON, MINN.

The Northwest Experiment Station at Crookston, Minn., is located on a heavy clay loam at an altitude of 863 feet. It has an average annual rainfall of 21.8 inches in a 26-year period. The experiments there have been conducted independently by the Minnesota Agricultural Experiment Station and are presented here through the courtesy of the director and his associates.

The data cover the period of five years from 1912 to 1916, inclusive, as shown in Table X and figure 8. Yields are given of three durum wheats of two different groups and of four common wheats, representing the three leading spring groups. The three durum varieties excel Glyndon, Haynes, and Preston by from 2 to 5 bushels per acre. Only the two durums in the Kubanka group outyield Marquis, however, and then by only 0.6 bushel in one case and 1.9 bushels in the other.

Table X.—*Annual and average yields of three varieties of durum wheat and four varieties of common wheat grown at the Northwest Agricultural Experiment Station, Crookston, Minn., during the five years from 1912 to 1916, inclusive.*

[Data presented by courtesy of the Minnesota Agricultural Experiment Station.]

Class, group, and variety.	Yield per acre (bushels).					
	1912	1913	1914	1915	1916	5-year average.
Durum:						
Kubanka—						
Mindum (Minn. No. 951)	33.4	21.6	22.3	34.5	16.6	25.7
Kubanka	32.2	27.8	14.6	38.0	9.6	24.4
Velvet Don—Velvet Don	28.2	25.3	13.4	32.6	11.6	22.2
Common:						
Fife—						
Marquis[a]	27.8	21.4	23.9	40.0	5.8	23.8
Glyndon (Minn. No. 163)	26.5	20.4	17.8	30.9	3.1	19.7
Preston—Preston	33.4	18.2	17.7	28.1	4.9	20.5
Bluestem—Haynes (Minn. No. 169)	38.5	17.4	19.2	23.3	2.2	20.1

[a] Average of the yields of two plats.

On the average, the durum varieties are the better at Crookston. Winter wheat can not be grown successfully in this locality, and only the Marquis approaches closely the best durums in yield. Among the three durum varieties under test, the Kubanka and a pure-line selection (Minn. No. 951) closely resembling Arnautka are better adapted than the Velvet Don. The Arnautka selection, which has been named Mindum by the Minnesota Agricultural Experiment Station, outyielded Kubanka in the 5-year test by 1.3 bushels per acre. Here, as at Brookings, S. Dak., Arnautka has proved to be slightly better adapted than Kubanka. The close agreement in yield between the Glyndon, Haynes, and Preston varieties is remarkable, showing that here all three groups of hard spring common wheat are at home. Farther east only the Bluestem group does well, but farther west it is decidedly inferior to the other two.

RESULTS AT FARGO, N. DAK.

Fargo is located on a heavy black clay loam at an altitude of 935 feet above sea level. Its normal annual rainfall is 24.9 inches. These data, in comparison with those from all the other stations, will be found in Table II (p. 15). The experiments here were conducted cooperatively by the North Dakota Agricultural Experiment Station and the Office of Cereal Investigations. The results obtained are presented in Table XI. The principal data are shown graphically also in figure 8.

The experiments cover seven years, 1901 to 1904, inclusive, and 1906 to 1908, inclusive. Eleven varieties of durum wheat are included, of which 10 belong to the Kubanka group. It is striking that among the 7-year average yields of these 10 there is a range of only 2.9 bushels. This difference is scarcely significant when the lowest and highest yields are, respectively, 33 and 35.9 bushels per acre. The difference in yield between the now commonly grown varieties, Arnautka and Kubanka, is not significant, although the slight difference is in favor of Kubanka. Here again the durums all outyield the best representatives of the standard spring common wheats by quantities that usually are significant. Winter wheat can not be grown successfully in this locality.

The Bluestem slightly excels Fife, and that in turn outyields Preston. In 1904, the year of a severe rust epidemic, the durums yielded better than common wheats. In 1906, however, the Bluestem outyielded all durums except Arnautka. A summary of the results shows that durum wheat yielded better than common wheat in the Red River Valley in the 7-year period, a conclusion fully in accord with farm yields in that district. Since 1908 the experiments have been conducted independently by the North Dakota Agricultural Experiment Station, but the results are not yet available.

Table XI.—*Annual and average yields of twelve varieties of durum wheat and three varieties of common wheat grown at the North Dakota Agricultural Experiment Station, Fargo, N. Dak., during periods of varying length in the seven years from 1901 to 1904 and 1906 to 1908, inclusive.*[a]

[Data obtained in coöperation with the North Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	N. Dak. No.	Yield per acre (bushels).								
			1901	1902	1903	1904	1906	1907	1908	Average.	
										4 years, 1901 to 1904.	7 years, 1901 to 1904 and 1906 to 1908.
Durum:											
Kubanka—											
Gharnovka	1447	917	32.4	30.3	46.5	23.6	24.0	47.8	47.0	33.2	35.9
Taganrog	1570	911	29.7	31.7	46.7	18.5	25.3	55.6	38.2	31.7	35.1
Pererodka	1350	328	34.7	25.7	47.0	17.8	24.3	54.6	39.2	31.3	34.8
Kubanka	1349	329	32.4	28.7	44.0	17.6	22.0	50.0	46.7	30.7	34.5
Yellow Gharnovka	1444	914	30.8	33.0	41.7	24.7	25.0	49.5	36.4	32.6	34.4
Kubanka	1440	929	32.4	28.7	44.0	21.9	24.3	50.0	38.5	31.8	34.3
Beloturka	1513	919	32.6	29.9	46.3	17.8	22.3	53.1	36.7	31.7	34.1
Arnautka	1494	778	34.0	28.7	43.4	20.5	27.3	49.6	33.2	31.7	33.8
Argentine	1569	910	28.4	29.5	44.6	24.0	23.5	52.5	29.2	31.6	33.1
Gharnovka	1443	915	31.4	25.8	44.5	20.8	24.6	48.0	36.0	30.6	33.0
Velvet Don—Velvet Don	1445	930	29.6	32.5	42.6	18.5	24.0	48.1	35.5	30.8	33.0
Common:											
Bluestem—Haynes	1505	779	29.7	21.2	39.3	15.2	26.3	[b]32.2	34.0	26.4	28.3
Fife—Power	1506	920	27.0	23.1	38.5	15.2	18.3	24.6	[c]26.2	26.0	24.7
Preston—Preston	2958	210	24.9	25.0	38.7	7.1	......	......	......	23.9	......

[a] The crop of 1905 could not be harvested, owing to rain.

[b] Yield of a selection (C. I. No. 3083, N. Dak. No. 316) from Haynes, C. I. No. 1505, substituted.

[c] Yield of a selection (C. I. No. 3697, N. Dak. No. 313) from Power, C. I. No. 1506, substituted.

RESULTS IN THE SEMIARID GREAT PLAINS AREA.

The Great Plains area includes parts of all the States and Provinces from Texas on the south to Manitoba, Saskatchewan, and Alberta on the north. Roughly speaking, it extends from the line of 30-inch rainfall westward to the Rocky Mountains. Under this definition it includes part of the territory just discussed as in the subhumid section. The separation made in this paper between semiarid and subhumid is not exactly the one commonly used and is made here only in order to permit a better interpretation of the behavior of durum wheat.

In altitude, this division rises from 1,000 or 1,500 feet on its eastern border to 2,000 or 3,000 feet through its central portion, and to maximum altitudes in the west of 6,000 feet in eastern Wyoming and of 6,500 feet in east-central Colorado. Figure 10 is a contour map of the Great Plains area in the United States on which the altitudes are indicated by lines drawn on the contours of 1,000, 1,500, 2,000, 3,000, 4,000, 5,000, and 6,000 feet. The drainage is to the southeast in the southern portion, to the east in the central portion, and to the northeast in the northern portion.

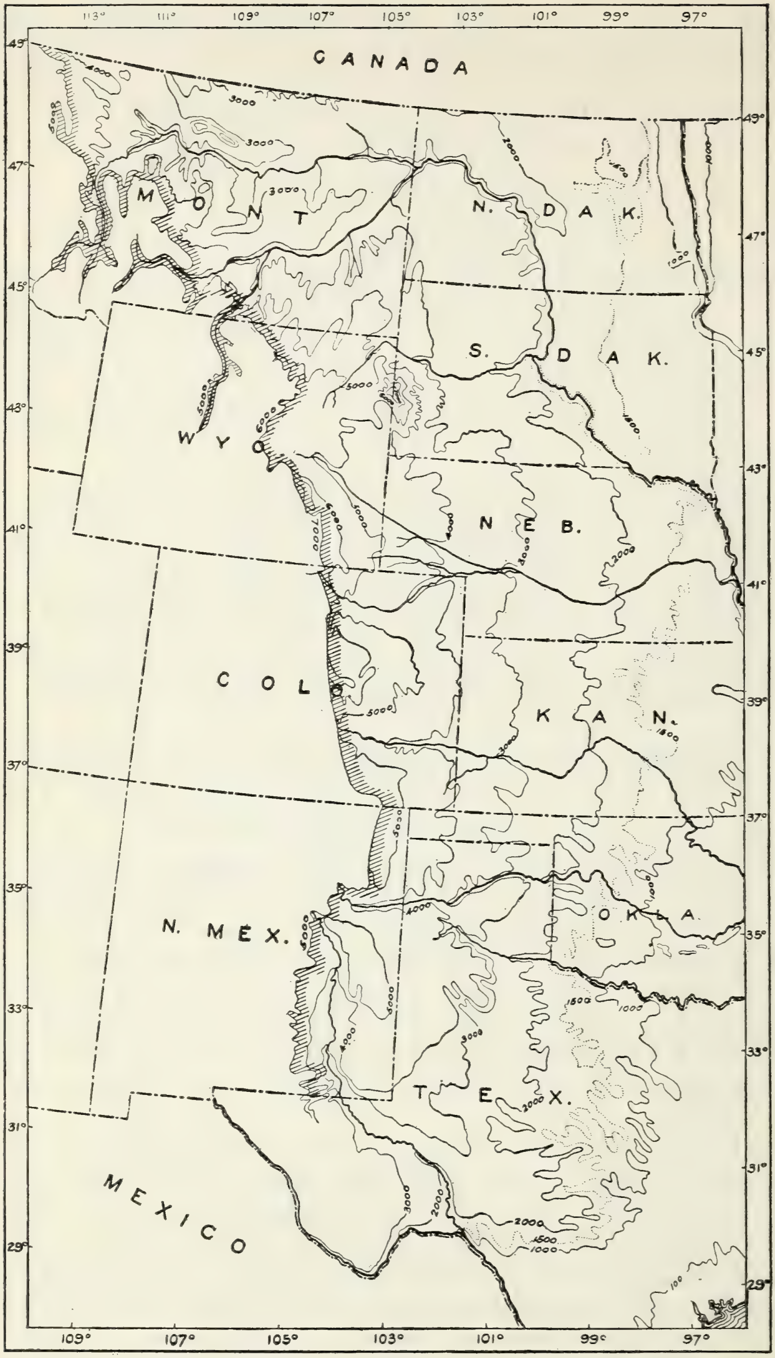

FIG. 10.—Map of the Great Plains area, showing the altitudes above sea level by means of lines following the contours at 1,000, 1,500, 2,000, 3,000, 4,000, 5,000, and 6,000 feet.

The climate is classed generally as semiarid. The average annual precipitation over most of this area varies from 14 to 20 inches. Only in the extreme southern part and along the eastern border is this quantity exceeded. In general, the annual rainfall decreases from east to west across the Great Plains with the increase in altitude. Figure 11 shows the distribution of precipitation in the Great Plains area of the United States by means of lines drawn through points having the same average precipitation.

Crop production is governed largely by the quantity and distribution of the annual rainfall. Half to two-thirds of it comes during the growing season, the four months from April to July, inclusive. Wind movement is fairly constant, and summer temperatures are rather high. These factors cause rapid loss of water by evaporation. Both hot winds and hail sometimes occur, though hot winds are not known at the higher altitudes. Wet weather in midsummer is conducive to rust infection, which frequently occurs locally and sometimes extends to a general epidemic throughout the area.

The length of the growing season varies with the altitude and latitude. The frost-free period decreases from about 130 days in the lower portions to about 90 days at the higher altitudes. In general, early varieties have an advantage in escaping hot winds, drought, and frost. A brief popular classification and description of the important groups of hard spring wheat and the leading varieties in each group is already available (Ball and Clark, 1915 *b*). Plants, spikes, and kernels of representative varieties of the chief groups of wheat grown in this area are shown in figures 4, 5, 6, 7, and 9.

Experiments conducted at 15 stations in the Great Plains area are discussed in the following pages. The name of each station, the altitude in feet above sea level, the normal or average rainfall, and the period of years on which it is based, together with the soil type on which each is located, are all shown in Table II (p. 15). Figure 12 is an outline map of this area, showing the location of each station and, by means of graduated columns, the average yield of the best variety of durum wheat and of the best variety of each group of common wheat during the years indicated. Thirteen of these stations are in the United States and two are in the Dominion of Canada. Durum wheat has been under test at the two Canadian stations since 1895. None of the experiments in the United States began earlier than 1902, as most of the stations were established later than that date. For the most part they are substations of the State agricultural experiment station or independent field stations of the United States Department of Agriculture.

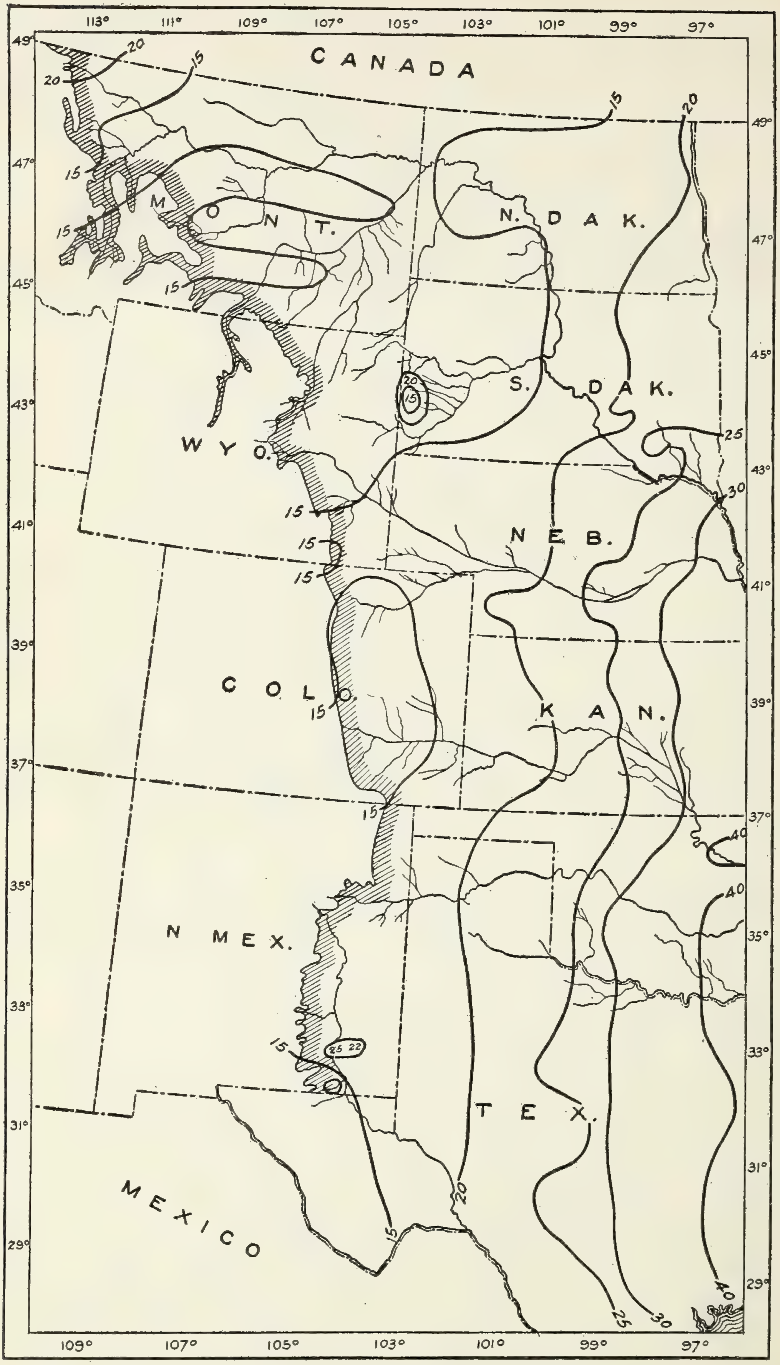

FIG. 11.—Map of the Great Plains area, showing the average yearly rainfall in inches by means of lines drawn through places having about the same rainfall.

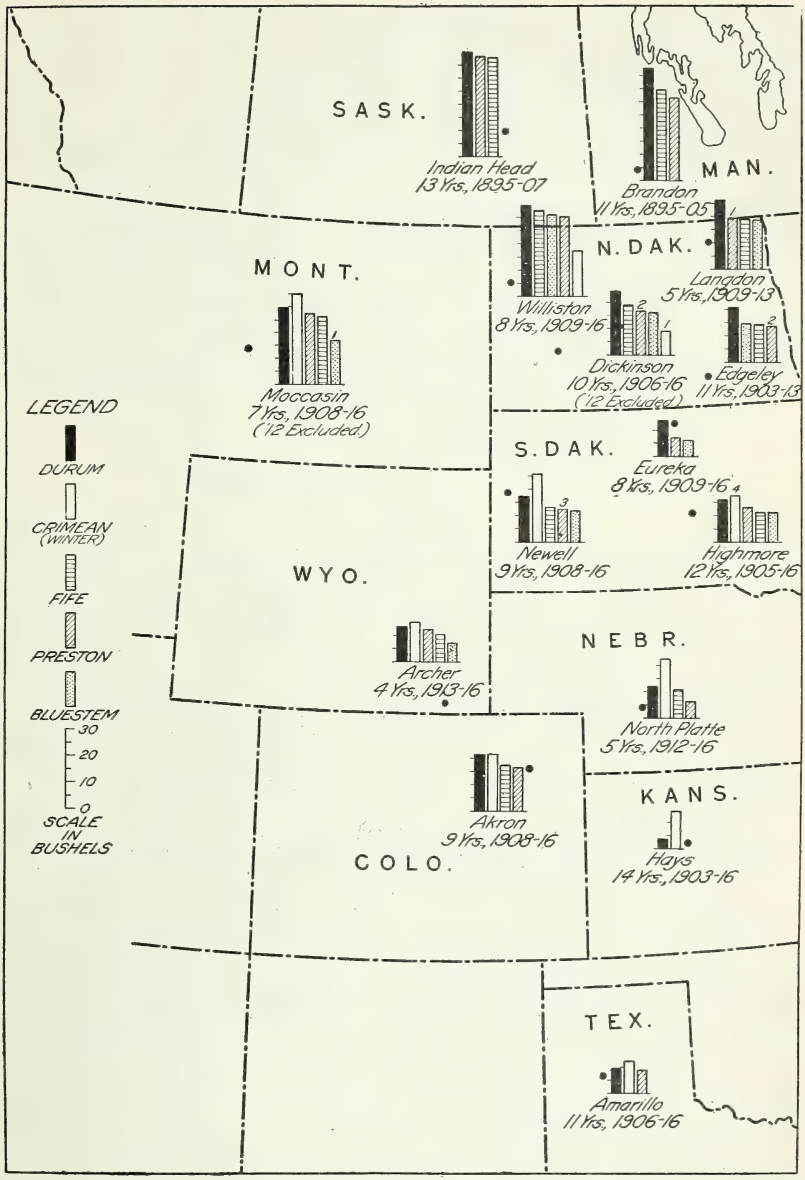

FIG. 12.—Diagram showing the location of fifteen stations in the Great Plains area and the average yield of the leading variety of durum wheat and the leading variety of each of several different groups of common wheat at each station during the periods of years indicated: 1, Average of only four years (Bluestem at Moccasin, Crimean at Dickinson, Preston at Langdon); 2, average of only six years (Preston at Dickinson and Edgeley); 3, average of only seven years (Preston at Newell); 4, average of only five years (Crimean at Highmore).

RESULTS AT AMARILLO, TEX.

The Amarillo Cereal Field Station is located in the center of the Texas Panhandle on a chocolate clay loam soil at an altitude of 3,676 feet. The average annual precipitation for the past 24 years is 21.2 inches. The experiments are conducted by the Office of Cereal Investigations in cooperation with the Amarillo Chamber of Commerce.

The data presented in Table XII and shown graphically in figure 12 cover the 11-year period from 1906, when the station was established, to 1916, inclusive. Three varieties of durum wheat belonging to two different groups have been grown throughout this period.

Table XII.—*Annual and average yields of three varieties of durum wheat and four varieties of common wheat grown at the Cereal Field Station, Amarillo, Tex., during the eleven years from 1906 to 1916, inclusive.*

[Data obtained in cooperation with the Amarillo Chamber of Commerce.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).											
		1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	Average, 11 years, 1906 to 1916.
Durum:													
Kubanka—													
Saragolla	2228–I	7.6	8.5	15.3	6.5	2.7	11.1	14.0	8.5	12.7	11.7	5.5	9.5
Marouani	2235–I	5.3	10.4	16.8	5.7	2.8	11.6	11.0	3.9	15.5	14.3	4.2	9.2
Kubanka	1440	8.0	4.3	16.8	5.9	3.1	9.3	14.5	4.9	12.5	7.3	3.9	8.2
Common:													
Crimean (winter)—Turkey	1558	25.8	3.3	23.2	0	10.2	1.6	16.0	6.5	26.8	19.2	4.3	12.4
Mediterranean (winter)—Diehl-Mediterranean	1395–2	18.5	1.4	25.8	0	10.4	.4	14.3	4.8	23.0	18.0	6.7	11.2
Preston—Fretes	1596	5.1	10.7	19.5	8.5	3.6	9.0	14.8	4.5	11.5	9.5	3.4	9.1
Galgalos—Galgalos	2398	4.9	10.6	18.0	7.5	3.9	11.0	13.7	4.8	8.7	7.8	1.6	8.4

The yields of one representative of each of the hard red and the soft red groups of winter wheat and of each of two groups of spring wheat are tabulated for comparison. Climatic conditions are severe, and no yields are high. Winter varieties are better adapted and yield better than any spring wheat. Among the groups of spring wheat there is little choice from the standpoint of yield. The little difference that exists is in favor of the durum varieties, but it is in no way significant, nor is there any marked difference in the performance of the durum varieties. Saragolla and Marouani have a slight advantage over Kubanka, the variety which is best adapted at many of the northern stations. The two former varieties came from the Mediterranean district, but the latter is of Russian origin.

RESULTS AT HAYS, KANS.

The Fort Hays Branch Experiment Station, as shown in Table II (p. 15), is located on a silty clay loam soil at an altitude of 2,000 feet above sea level. During a 48-year period the normal annual rainfall has been 23.2 inches. The experiments there have been conducted cooperatively by the Kansas Agricultural Experiment Station and the Office of Cereal Investigations.

The data discussed in this paper are presented in Table XIII and are seen in graphic form in figure 12. They cover a period of 14 years, 1903 to 1916, inclusive.

TABLE XIII.—*Annual and average yields of two varieties of durum wheat and one variety of common wheat grown at the Fort Hays (Kans.) Branch Experiment Station during periods of varying length in the fourteen years from 1903 to 1916, inclusive.*

[Data obtained in cooperation with the Kansas Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).															
																Average.	
		1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	5 years, 1912 to 1916.	14 years, 1903 to 1916.
Durum:																	
Kubanka—																	
Marouani......	2235-I	....	....	....	....	....	....	....	....	....	12.2	3.8	7.0	11.8	5.2	8.0	......
Kubanka......	1440	0	1.7	0	2.2	0	8.4	0	18.1	0.1	8.2	2.1	1.2	7.8	3.5	4.6	3.8
Common:																	
Crimean (winter)—																	
Crimean..........	1437	33.2	10.7	5.9	5.2	4.3	26.1	0	17.6	2.2	17.7	15.6	22.6	6.3	37.0	19.8	14.6

The varieties tested throughout this period include only two, viz, Kubanka of the durum class and Crimean of the hard red winter group of common wheat. During this period the Crimean outyielded the Kubanka in the ratio of nearly 4 to 1, although the Crimean yield is only 14.6 bushels per acre. Tests during the last five years show that Marouani is better adapted than Kubanka. This part of Kansas is strictly a winter-wheat district, and spring wheat can not be profitably grown.

RESULTS AT AKRON, COLO.

The Akron Field Station of the Office of Dry-Land Agriculture, at Akron, Colo., lies at an altitude of 4,560 feet on a sandy loam soil. The average annual rainfall for the past 11 years was 19.7 inches. The experiments discussed herein were conducted by the Office of Cereal Investigations in cooperation with the Office of Dry-Land Agriculture of the Bureau of Plant Industry.

The results of the experiments are presented in Table XIV, and the principal data are shown in graphic form in figure 12. The data are for the nine years from 1908 to 1916, inclusive. Yields are shown for 11 durum varieties tested during seven of these years and of four for all nine years. The most striking fact is the close agreement in yield of the best durum varieties and the Crimean winter wheat. The average yield of the Crimean is reduced by its complete failure in 1909. This was due, in part, to a treatment of the seed with formaldehyde which was too severe, resulting in a poor stand, which entirely winterkilled.

Among the spring wheats, the ordinary Fife and Bluestem varieties do not yield well at Akron, so the Fife group is represented by Ghirka Spring, and in the last four years by Marquis also. The Bluestem group is absent. The Preston group is represented by Erivan from the Caucasus region. Neither Ghirka Spring nor Erivan is able to compete with the best durum varieties in yield. From the records made by the Marquis in the four years since it was included in the test, it may prove to be more nearly equal to the durums than any other spring common varieties. From the data now available, however, the durums are the best spring wheats to grow at this station.

TABLE XIV.—*Annual and average yield of eleven varieties of durum wheat and four varieties of common wheat grown at the Akron Field Station, Akron, Colo., during periods of varying length in the nine years from 1908 to 1916, inclusive.*

[Data obtained in cooperation with the Office of Dry-Land Agriculture.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).											
		1908	1909	1910	1911	1912	1913	1914	1915	1916	Average.		
											7 years, 1908 to 1914.	7 years, 1910 to 1916.	9 years, 1908 to 1916.
Durum:													
Pelissier—Pelissier	1584	24.7	23.6	15.8	10.6	35.6	10.5	26.6	31.6	14.4	21.1	20.7	21.5
Kubanka—													
Arnautka	4064	.....	.....	19.5	15.7	37.3	10.6	25.0	27.6	11.4	......	21.0	......
Do	1493	26.9	20.8	16.6	10.6	27.5	10.5	27.6	27.9	10.7	20.1	18.7	19.9
Beloturka	1520	31.1	19.4	19.9	8.0	21.1	10.6	19.5	26.7	11.4	18.5	16.7	18.6
Kubanka	1440	26.8	9.3	17.1	9.0	25.1	5.1	20.7	27.6	12.9	16.2	16.8	17.1
Yellow Gharnovka	1444	32.8	25.1	15.0	10.8	34.2	5.3	22.5	.....	.....	20.9	......	......
Gharnovka	1447	29.1	20.9	13.1	9.3	36.5	3.3	23.7	.....	.....	19.3	......	......
Kubanka	1354	27.2	18.0	21.3	11.7	19.8	13.6	22.7	.....	.....	19.2	......	......
Marouani	1593	22.9	14.2	19.3	10.6	19.0	14.1	24.0	.....	.....	17.7	......	......
Velvet Don—Velvet Don	1445	33.3	21.1	13.5	10.0	33.3	7.3	25.3	.....	.....	20.5	......	......
Kahla—Purple	3024	24.8	20.8	15.3	7.9	33.0	10.0	21.2	.....	.....	19.0	......	......
Common:													
Crimean (winter)—Crimean	1436	19.1	0	36.3	17.9	33.1	12.6	28.3	26.6	20.5	21.3	25.0	21.6
Fife—Ghirka Spring	1517	20.6	23.8	18.8	8.5	23.4	14.0	19.3	22.6	7.5	18.3	16.3	17.6
Marquis	3641	.....	.....	.....	.....	.....	7.5	19.7	26.5	11.8	......	......	......
Preston—Erivan	2397	19.3	26.3	15.2	11.9	20.7	12.0	19.3	19.5	7.8	17.8	15.2	16.9

Considering only the durum wheats, Pelissier leads in the first 7-year average and the 9-year average and almost ties with Arnautka for first place in the second 7-year average. In the Kubanka group a pure line, Arnautka 6P1 (C. I. No. 4064), a selection of Arnautka

(C. I. No. 1494), leads in the 7-year period in which it was grown. The unselected Arnautka (C. I. No. 1493) stands next to Pelissier in the 9-year period. In the first 7-year period, however, Yellow Gharnovka of the Kubanka group is the highest yielder, followed by Velvet Don, type of a different group, and Arnautka (C. I. No. 1493) ranks third. The Yellow Gharnovka and Velvet Don were discarded at the end of the seven years in spite of their high average rank, but Beloturka and Kubanka were continued. The low average yield of Kubanka is in part due to a poor stand obtained in 1909, which resulted in a very low yield that year. Omitting 1909, which was also the year of failure for winter wheat, the difference in yield during the eight remaining years between the three varieties of the Kubanka group is hardly significant. The Pelissier exceeds the best of the Kubanka group in these eight years by 1.6 bushels, but in turn is exceeded in yield by Crimean winter wheat by 3.1 bushels per acre.

RESULTS AT NORTH PLATTE, NEBR.

The North Platte substation is located in the valley of the South Platte River, just above the junction of the North and South Forks. It lies at an altitude of 3,000 feet and is located on the porous clay-loam soil known as loess. The normal annual rainfall is 18.9 inches. The cereal experiments were conducted independently by the Nebraska Agricultural Experiment Station, and the results are made available here through the courtesy of the director and his associates.

TABLE XV.—*Annual and average yields of six varieties of durum wheat and three varieties of common wheat grown at the North Platte (Nebr.) substation during periods of varying length in the eleven years from 1906 to 1916, inclusive.*

[Data used by courtesy of the Nebraska Agricultural Experiment Station.]

Class, group, and variety.	Yield per acre (bushels).													
												Average.		
	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	5 years, 1906 to 1910.	5 years, 1912 to 1916.	11 years, 1906 to 1916.
Durum:														
Kubanka—														
Gharnovka	22.6	31.4	32.2	28.0	3.4	0	6.7	7.2	3.0	24.1	20.0	23.5	12.2	16.2
Kubanka No. 1	......	......	......	......	......	......	3.2	7.7	3.9	25.1	19.5	......	11.9	......
Kubanka [a]	18.6	33.0	30.3	26.5	3.5	0	6.5	7.9	2.3	21.6	19.9	22.4	11.6	15.5
Kahla—														
Black Don	22.8	28.6	32.5	27.2	3.5	......	......	......	......	......	......	22.9	......	......
Kahla	......	......	......	......	......	......	6.7	9.8	2.9	19.2	18.4	......	11.4	......
Velvet Don—Velvet Don	23.4	29.0	30.8	25.5	2.5	0	5.1	8.9	4.0	......	......	22.2	......	......
Common:														
Crimean (winter)—Turkey [b]	......	......	......	......	......	......	9.9	16.8	8.0	37.3	38.3	......	22.1	......
Fife—Marquis	......	......	......	......	......	......	4.6	6.8	4.3	20.2	17.4	......	10.7	......
Preston—Preston [c]	......	......	......	......	......	......	3.0	3.0	3.0	6.6	16.2	......	6.4	......

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[a] Average yields from two plats.

[b] Average yields from nine plats in the rotations of the Office of Dry-Land Agriculture Investigations.

[c] This variety was grown under the name Scotch Fife.

The experiments with durum wheat date from 1906. The data are given in Table XV and the principal facts graphically in figure 12.

The results show that there is little difference in the yielding power of several different varieties under the prevailing conditions at North Platte. The vicissitudes attendant upon grain growing, however, are clearly shown by the yields in the 5-year period, 1912 to 1916, inclusive, which are only about half as large as those in the 5-year period, 1906 to 1910, inclusive. Comparison of durum yields with those of other wheats can be made only in the second 5-year period. The yield of Turkey is nearly double that of the durum varieties. Marquis does not quite equal the yield of the poorest durum and falls 1.5 bushels below that of the best durum. Preston is much poorer than Marquis. To summarize, winter wheat of the Crimean group ranks first, while the durums outyield any spring common wheat so far tried.

The differences in yield between the different durum varieties are scarcely large enough to be significant. The Kubanka group outyields either Kahla or Velvet Don, and the Gharnovka outyields Kubanka within the group.

RESULTS AT ARCHER, WYO.

The Cheyenne Field Station at Archer, Wyo., is located on a fairly sandy loam containing some gravel. The altitude is almost exactly 6,000 feet above sea level. The normal rainfall is only 14.2 inches. These records are mostly from Fort D. A. Russell at Cheyenne, 9 miles distant, where conditions probably are slightly more favorable than at Archer. The conditions of high altitude and northern latitude allow only a short growing season, and this, combined with the low rainfall, makes crop growing somewhat difficult. The experiments are conducted by the Office of Cereal Investigations in cooperation with the Wyoming State Board of Farm Commissioners.

The results of experiments conducted with wheat in the four years 1913 to 1916, inclusive, or since the establishment of the station, are shown in Table XVI, and the principal results graphically in figure 12. Here, as at Akron, the number of durum varieties is large, no less than 14 having been tested during all or a part of this period. Here again there is a close agreement between the yields of the hard red winter wheats and the best durums, the Turkey having a slightly higher yield. The best durum varieties again outyield the Erivan and also the Marquis by small quantities. The Haynes Bluestem is decidedly outclassed by the durums.

From a study of Table XVI it is evident that no less than five varieties of the Kubanka group have outyielded the representatives of the other groups of spring wheat. This is true in both the 3-year and the 4-year periods, and four of the outstanding varieties are the same in both periods. These four are Kubanka (C. I. No. 1516), Beloturka, Pererodka, and Kubanka (C. I. No. 1440), named in the order of their 4-year rank. Pelissier, which was the highest yielding variety at Akron, Colo., makes a fair yield at Archer, but ranks eighth in the 3-year average and sixth in the 4-year average. From the data at hand the durums of the Kubanka group seem to be the spring wheats best adapted for this district.

Table XVI.—*Annual and average yields of fourteen varieties of durum wheat and four varieties of common wheat grown at the Cheyenne Field Station, Archer, Wyo., during periods of varying length in the four years from 1913 to 1916, inclusive.*

[Data obtained in cooperation with the Wyoming State Board of Farm Commissioners.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).					
		1913	1914	1915	1916	Average.	
						3 years, 1913 to 1915.	4 years, 1913 to 1916.
Durum:							
Kubanka—							
Kubanka	1516	7.1	13.0	27.6	6.5	15.9	13.6
Beloturka	1520	7.7	11.9	28.9	5.1	16.2	13.4
Pererodka	1350	8.3	12.8	26.0	5.4	15.7	13.1
Kubanka	1440	7.5	12.5	25.6	5.8	15.2	12.9
Arnautka	1493	7.2	12.3	23.8	6.1	14.4	12.4
Marouani	1593	7.9	11.5	21.5	7.6	13.6	12.1
Arnautka	4064	6.4	10.7	23.6	6.9	13.6	11.9
Yellow Gharnovka	1444	7.8	11.5	25.9	......	15.1	....
Gharnovka	1447	7.5	12.3	24.1	......	14.6	....
Kubanka	1354	7.7	12.8	22.1	......	14.2	....
Pelissier—							
Pelissier	1584	8.7	11.6	22.6	5.9	14.3	12.2
Saragolla	2228	6.7	10.3	18.8	......	11.9	....
Velvet Don—Velvet Don	1445	8.6	10.8	24.4	......	14.6	....
Kahla—Purple	3024	7.5	10.5	22.8	......	13.6	....
Common:							
Crimean (winter)—Turkey	1571	10.0	7.9	32.0	10.0	16.6	15.0
Preston—Erivan	2397	9.4	9.5	22.0	7.5	13.6	12.1
Fife—Marquis	3641	9.0	8.4	20.9	5.4	12.8	10.9
Bluestem—Haynes	2874	4.4	9.0	11.7	5.0	8.4	7.5

RESULTS AT HIGHMORE, S. DAK.

The Highmore substation of the South Dakota Agricultural Experiment Station is located on a glacial clay loam soil at an altitude above sea level of 1,890 feet. The average annual rainfall has been 16.7 inches during the last 22 years. The cereal experiments were conducted by the South Dakota Agricultural Experiment Station in cooperation with the Office of Cereal Investigations.

The experiments were begun in 1902. The data obtained are shown in Table XVII, and the principal facts are presented graphically in figure 12. No less than 26 durum varieties were tested in the first three or four years. Only nine of these, all in the Kubanka group, were carried for a long period of time. Cropping conditions are sometimes precarious in this locality. Almost complete failures are recorded in 1911 and 1912, and the yields in 1910 and 1913 were very low

TABLE XVII.—*Annual and average yields of twenty-seven varieties of durum wheat and six varieties of common wheat grown at the Highmore (S. Dak.) substation during periods of varying length in the fifteen years from 1902 to 1916, inclusive.*

[Data obtained in cooperation with the South Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).																		
																	Average.			
		1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	4 years, 1902 to 1905.	10 years, 1903 to 1912.	12 years, 1905 to 1916.	4 years, 1913 to 1916.
DURUM.																				
Kubanka:																				
Kubanka	1440	22.3	15.2	23.8	23.2	26.7	28.7	22.7	17.0	8.0	0	1.1	2.0	19.7	33.3	12.2	21.1	16.6	16.2	16.8
Arnautka	(1)	....	17.8	16.8	38.7	20.0	22.5	25.0	12.7	1.7	0	.8	2.8	8.9	38.3	7.5	....	15.6	14.9	14.4
Kubanka	1516	....	10.7	23.3	28.5	31.2	26.8	27.5	14.8	13.0	0	.7	4.2	....	....	....	....	17.7	....	....
Do	1354	....	12.8	20.3	27.0	27.2	29.7	23.8	19.5	12.2	0	.8	3.3	22.2	30.0	....	....	17.3	....	....
Pererodka	1350	....	15.9	21.2	28.3	28.5	27.3	22.0	17.2	6.2	0	0	....	....	....	....	....	16.7	....	....
Arnautka	1537	....	16.2	18.0	36.0	22.0	22.7	25.0	15.8	2.0	0	0	....	....	....	....	....	15.8	....	....
Beloturka	1513	....	14.0	12.3	35.8	22.8	24.2	27.8	12.5	2.0	0	1.6	4.4	....	....	....	....	15.3	....	....
Kubanka	1541	....	10.0	23.2	26.7	25.5	21.7	22.5	10.7	8.3	0	0	....	....	....	....	....	14.9	....	....
Arnautka	4072	....	....	....	36.7	23.8	23.8	26.0	14.2	5.0	0	0	....	8.9	30.0	....	....	....	....	....
Taganrog	1570	24.3	18.5	13.3	35.0	....	....	....	....	....	....	....	....	....	....	....	22.8	....	....	....
Berdiansk	1586	29.4	15.8	12.7	33.0	....	....	....	....	....	....	....	....	....	....	....	22.7	....	....	....
Kubanka	2094	22.3	16.7	23.3	26.5	22.8	....	....	....	....	....	....	....	....	....	....	22.2	....	....	....
Yellow Gharnovka	2096	29.6	18.2	10.5	26.7	....	....	....	....	....	....	....	....	....	....	....	21.3	....	....	....
Argentine	1569	20.0	17.0	10.7	33.3	....	....	....	....	....	....	....	....	....	....	....	20.3	....	....	....
Kubanka	2234	20.0	13.5	22.3	24.3	....	....	....	....	....	....	....	....	....	....	....	20.0	....	....	....
Yellow Gharnovka	1444	23.2	18.7	11.3	25.2	....	....	....	....	1.8	0	.4	3.3	29.3	33.3	10.0	19.6	....	....	19.0
Gharnovka	1443	24.0	15.5	13.5	24.2	....	....	....	....	....	....	....	....	....	....	....	19.3	....	....	....
Marouani	1593	22.3	11.7	14.0	29.2	....	....	....	....	....	....	....	....	....	....	....	19.3	....	....	....
Gharnovka	1447	22.2	14.7	11.8	24.0	....	....	....	....	....	....	....	....	....	....	....	18.2	....	....	....
Acme	5284	....	....	....	....	....	....	....	....	....	....	....	....	30.0	31.7	22.0	....	....	....	....
Velvet Don: Velvet Don	1445	29.3	18.8	12.5	27.2	....	....	....	....	....	....	....	....	....	....	....	22.0	....	....	....
Pelissier:																				
Medeah	1597	23.7	14.0	11.0	31.8	....	....	....	....	....	....	....	....	....	....	....	20.1	....	....	....
Mohamed ben Bachir	2087	16.8	11.8	14.7	36.7	....	....	....	....	....	....	....	....	....	....	....	20.0	....	....	....
Pelissier	1584	26.5	17.8	14.0	20.8	....	....	....	....	....	....	....	....	....	....	....	19.8	....	....	....
Do	2086	22.2	20.2	12.3	22.5	....	....	....	....	....	....	....	....	....	....	....	19.3	....	....	....
Kahla:																				
Kahla	1595	17.3	11.2	11.3	35.8	....	....	....	....	....	....	....	....	....	....	....	18.9	....	....	....
Do	2088	14.4	9.0	13.7	32.0	....	....	....	....	....	....	....	....	....	....	....	17.3	....	....	....
COMMON.																				
Crimean (winter): Kharkof	1442	....	....	....	....	....	....	....	....	....	....	3.7	2.1	12.5	31.7	39.2	....	....	....	21.4
Fife:																				
Marquis	3641	....	....	....	....	....	....	....	....	....	....	....	12.7	13.3	33.3	6.3	....	....	....	16.4
Power	2989	....	....	....	20.5	14.8	12.5	16.1	16.5	10.3	0	0	6.3	8.7	26.7	5.0	....	....	11.5	11.7
Ghirka Spring	1517	....	14.0	8.0	26.0	22.0	15.0	4.8	17.7	6.2	0	2.4	6.5	11.3	16.7	7.2	....	11.1	10.9	10.4
Preston: Preston	3081	....	....	....	25.5	20.3	18.7	11.0	17.5	6.8	.3	.5	6.5	12.0	35.8	7.0	....	....	13.5	15.3
Bluestem: Haynes (Minn. No. 51)	1505	....	....	....	22.8	17.0	16.0	16.3	15.8	9.5	0	0	7.7	4.8	22.5	1.7	....	....	11.2	9.2

[1] Yields of Arnautka C. I. No. 1493 are shown for 1903 to 1910; C. I. No. 1547 for 1911 to 1913; C. I. No. 4072 for 1914; C. I. No. 4064 for 1915 and 1916.

The record of the yields is favorable to the durum wheats in comparison with spring common wheat. The best of the latter in a 12-year average has been Preston, but its yield of 13.5 bushels is 1.4 bushels below that of Arnautka and 2.7 bushels below that of Kubanka. Power and Haynes fall 2 and 2.3 bushels, respectively, below Preston.

During the last four years the Marquis has been included in the experiment. In 4-year average yield it outranks Preston by 1.1 bushels and Arnautka by 2 bushels. It falls behind Kubanka by only 0.4 of a bushel. Yellow Gharnovka durum, reintroduced into the test, has proved the best yielder of all, however, in this period, its yield of 19 bushels exceeding that of Kubanka by 2.2 bushels and that of Marquis by 2.6 bushels. Kharkof, a hard red winter wheat of the Crimean group, also has been grown during this 4-year period, and its yield of 21.4 bushels exceeds even that of the Yellow Gharnovka by 2.4 bushels.

From present indications it may be concluded that the Crimean wheats will outyield spring wheats here when they survive the winters. This station is about the present northern limit of winter-wheat production in central and eastern South Dakota. Good durum varieties will regularly outyield any spring variety now known, but Marquis and Preston are both good yielding varieties of spring common wheat in central South Dakota.

Among the durum wheats, Kubanka has given the highest yields of any variety tested in the 10-year and 12-year periods. In the 10-year period, three lots of Kubanka are among the four highest yielders, the other being Pererodka, which ranked third. In the last four years, however, Kubanka was outyielded by Yellow Gharnovka by 2.2 bushels. In the first 4-year period, 1902–1905, inclusive, three varieties, Taganrog, Berdiansk, and Yellow Gharnovka, all outyielded any Kubanka. Kubanka (C. I. No. 2094) also outyielded Kubanka (C. I. No. 1440), which was continued in the experiments, whereas the four varieties previously named were all dropped. Of the several lots or pure strains of Arnautka included in the tests, none has exceeded Kubanka consistently for any series of years. A selection of Kubanka (C. I. No. 1516), recently named Acme and assigned C. I. No. 5284, has been included in the experiments during only the last three years. This pure line has shown remarkable rust resistance, and as a result has outyielded all other wheats grown in the 3-year period from 1914 to 1916. In 1916 it was grown also at Brookings, S. Dak., where it outyielded all other spring wheats.

RESULTS AT EUREKA, S. DAK.

The Eureka substation of the South Dakota Agricultural Experiment Station is located on the remains of an old terminal moraine, the resulting soil being a stony sandy loam. The altitude is 1,884 feet, and the average annual rainfall during the last seven years has been 16.4 inches. The experiments were conducted independently by the South Dakota Agricultural Experiment Station until 1912, and since then in cooperation with the Office of Cereal Investigations.

The data presented in Table XVIII and shown graphically in figure 12 cover a period of eight years, from 1909 to 1916, inclusive. Only three varieties, one durum and two spring common wheats, were grown throughout the period. The 8-year average yield of the Kubanka durum is nearly double that of Preston and more than double that of Dakota Bluestem. The same facts are apparent in comparing the average yields of the same varieties in the last three years, 1914 to 1916, inclusive. During this period, however, Marquis was grown. This variety produced a yield 5.7 bushels higher than that of Preston and only 3.3 bushels lower than that of Kubanka.

TABLE XVIII.—*Annual and average yields of one variety of durum wheat and three varieties of common wheat grown at the Eureka (S. Dak.) substation during periods of varying length in the eight years from 1909 to 1916, inclusive.*

[Data obtained in cooperation with the South Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).									
		1909	1910	1911	1912	1913	1914	1915	1916	Average. 3 years, 1914 to 1916.	Average. 8 years, 1909 to 1916.
Durum:											
Kubanka—Kubanka	1440	22.5	10.7	0	0	15.1	9.3	42.9	10.3	20.8	13.9
Common:											
Fife—Marquis	3641	......	......	......	......	......	9.7	35.5	7.4	17.5	......
Preston—Preston	3081	12.5	3.8	0	1.5	7.7	10.7	22.9	1.7	11.8	7.6
Bluestem—Dakota	3083	10.1	2.3	0	5.2	8.7	6.6	18.5	.4	8.5	6.5

Beyond question, the durum wheats are better adapted to this district than are any spring common wheats yet known. Although no other variety than Kubanka has been grown, the evidence from other stations similarly located indicates Kubanka to be the best variety under these conditions.

RESULTS AT NEWELL, S. DAK.

The Belle Fourche Experiment Farm is located at an altitude of 2,900 feet on the Belle Fourche Reclamation Project, northeast of the Black Hills. The soil is a heavy clay with shale subsoil, known geologically as Pierre clay and popularly as gumbo. The average annual rainfall is only 14.1 inches, as shown by the records of eight years. The station is maintained by the Office of Western Irrigation Agriculture, and the cereal experiments are conducted by the Office of Cereal Investigations in cooperation with that office, and since 1912 in cooperation with the South Dakota Agricultural Experiment Station. Though the station is irrigated, the experiments discussed were conducted under dry-land conditions on ground wholly above the ditch.

The combination of high altitude and northern location permits only a rather short growing season. Add to this the low rainfall and it is seen that cropping under dry-land conditions is somewhat handicapped. The results since the station was established in 1908 are shown in Table XIX and the principal data graphically in figure 12. The difficulties experienced are indicated by the complete failures in 1911 and 1912 and the very low yields of spring varieties in 1910 and 1914.

TABLE XIX.—*Annual and average yields of five varieties of durum wheat and five varieties of common wheat grown on the Belle Fourche Experiment Farm, Newell, S. Dak., during periods of varying length in the nine years from 1908 to 1916, inclusive.*

[Data obtained in cooperation with the Office of Western Irrigation Agriculture and, since 1912, with the South Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).											
		1908	1909	1910	1911	1912	1913	1914	1915	1916	Average.		
											4 years, 1913 to 1916.	7 years, 1910 to 1916.	9 years, 1908 to 1916.
Durum:													
Kubanka—													
Kubanka	1516	23.8	22.6	5.3	0	0	19.1	9.6	54.5	19.7	25.7	15.5	17.2
Arnautka	1493	22.3	22.6	8.3	0	0	17.1	9.5	54.9	14.8	24.1	14.9	16.6
Pererodka	1350	22.5	23.2	5.2	0	0	16.7	9.7	58.2	13.7	24.6	14.8	16.6
Kubanka	1440	24.9	21.4	7.4	0	0	15.6	[a]9.5	54.4	13.8	23.3	14.4	16.3
Yellow Gharnovka	1444	22.7	20.9	5.0	0	0	16.5	7.4	54.0	......	......	......	[b]15.7
Common:													
Crimean (winter)—													
Kharkof	1442	25.4	40.3	22.7	0	0	38.6	28.7	63.8	14.2	36.3	24.0	26.0
Preston—Preston	3081	......	......	9.2	0	0	19.5	7.2	46.9	5.8	19.9	12.6	......
Fife—													
Marquis	3276	......	......	......	....	....	16.8	8.0	50.9	8.1	21.0	......	......
Power	3025	18.5	17.3	10.6	0	0	16.6	5.1	43.4	6.5	17.9	11.7	13.1
Bluestem—Haynes (Minn. No. 169)	3020	18.3	13.8	9.0	0	0	14.1	5.1	42.0	5.6	16.7	10.9	12.0

[a] Computed from yields of Kubanka, C. I. No. 1516.

[b] Average for only 8 years, 1908 to 1915, inclusive.

The data presented show clearly certain facts. Hard red winter wheat of the Crimean group outyields any spring variety in all years except 1916, when Kharkof was outyielded by Kubanka and Arnautka durums. In average yields the Kharkof outranks Kubanka by fully 50 per cent.

The five durum spring wheats, all of the Kubanka group, excel any spring common wheat by yields that are significant. In the four years during which it has been grown Marquis is the best yielder of the spring common wheats. It outyields Preston, the highest yielding variety in the 7-year period, by more than 1 bushel, but falls 4.7 bushels per acre behind the best Kubanka. In short, the durum varieties are the best spring wheats for the Belle Fourche district.

The Kubanka (C. I. No. 1516) leads in yield by an annual average of about half a bushel in the 9-year period. This quantity is not significant, and there is little choice among the four durum varieties which were grown throughout this period. No varieties of any other groups of durum wheat were under experiment during the periods of years shown.

RESULTS AT EDGELEY, N. DAK.

The Edgeley substation of the North Dakota Agricultural Experiment Station is located on a light sandy loam soil with a shale subsoil. It lies at an altitude of 1,468 feet and has an average annual rainfall of 18 inches for 15 years. The experiments were conducted independently by the North Dakota Agricultural Experiment Station, and the data presented are from the published annual reports of the substation. Experiments were begun in 1903 and have been published up to and including 1913.

The data found in Table XX were obtained from the annual reports of the Edgeley substation of the North Dakota Agricultural Experiment Station for the years 1903 to 1913, inclusive (Thompson, 1904–1914), and the principal facts are portrayed graphically in figure 12. Eleven-year records are given for five durum varieties representing two different groups and for one variety in each of two groups of spring common wheat. No continued attempt was made to grow winter wheat. The tabulated average yields show that all five of the durums outyielded the best spring common varieties in this period by 5 to 6 bushels per acre, which is equivalent to 30 per cent or more.

TABLE XX.—*Annual and average yields of five varieties of durum wheat and four varieties of common wheat grown at the Edgeley (N. Dak.) substation during periods of varying length in the eleven years from 1903 to 1913, inclusive.*

Class, group, and variety.	C. I. No.	Edgeley No.	Yield per acre (bushels).												
			1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	Average.	
														6 years, 1908 to 1913.	11 years, 1903 to 1913.
Durum:															
Kubanka—															
Arnautka	3693	5	19.4	31.3	42.1	27.2	13.8	13.5	27.6	2.3	1.6	32.9	25.2	17.2	21.5
Pererodka	1350	7	21.4	25.0	42.1	23.8	11.0	13.7	29.0	3.4	2.4	31.3	25.1	17.5	20.7
Gharnovka	1443	9	20.6	30.8	39.0	23.8	12.5	12.9	28.5	2.8	2.4	22.6	28.6	16.3	20.4
Kubanka	1440	6	18.2	21.5	43.4	21.4	13.2	11.3	28.5	3.4	2.0	33.4	25.1	17.3	20.1
Velvet Don—Velvet Don.	1445	8	20.3	35.2	43.2	19.3	15.6	11.3	29.6	2.3	2.0	23.0	21.5	15.0	20.3
Common:															
Preston—Preston	2958	188	....	....	....	....	....	9.6	17.3	7.9	3.2	21.6	26.9	14.4	......
Bluestem—Haynes	3021	2	15.1	11.6	30.3	15.6	6.5	9.6	19.4	6.7	2.0	26.4	21.5	14.3	15.0
Fife—Rysting	3022	3	19.7	11.6	29.4	12.3	6.2	10.1	20.3	6.2	1.6	21.7	25.2	14.2	14.9

The most striking fact in Table XX is the very close agreement of average yields for long periods. The average yields of the five durum varieties in the 11-year period range only from 20.1 bushels to 21.5 bushels per acre. The yield of Haynes is 15 bushels and of Rysting 14.9 bushels in the same period. In the 6-year period, 1908–1913, inclusive, Preston, Rysting, and Haynes vary only 0.2 bushel in average yield.

In the Edgeley district a durum wheat is decidedly the best wheat to grow. This conclusion is borne out also by the fact that the greatest density of durum production is in that section of the State. Among the five varieties tested, Arnautka has proved slightly the best adapted, outyielding Kubanka by 1.4 bushels in all 11 years. This result is in accord with those obtained at Brookings, S. Dak., and Crookston, Minn., discussed in the subhumid prairie section.

RESULTS AT LANGDON, N. DAK.

The Langdon substation of the North Dakota Agricultural Experiment Station is located on a black clay-loam soil at an altitude of 1,615 feet. The average annual rainfall in a 4-year period has been 17.9 inches. The substation is operated independently by the North Dakota Agricultural Experiment Station, and the results obtained have been published in annual reports, from which source they are presented here (Stewart, 1910–1914).

Data are available for only the five years, 1909 to 1913, inclusive. These are found in Table XXI, and the principal ones in figure 12. The results are all definitely and significantly in favor of the durum wheats.

TABLE XXI.—*Annual and average yields of six varieties of durum wheat and three varieties of common wheat grown at the Langdon (N. Dak.) substation during periods of varying length in the five years from 1909 to 1913, inclusive.*

Class, group, and variety.	C. I. No.	Yield per acre (bushels).							
							Average.		
		1909	1910	1911	1912	1913	4 years, 1909 to 1912.	4 years, 1910 to 1913.	5 years, 1909 to 1913.
Durum:									
Kubanka—									
Arnautka	1494	30.8	15.3	29.4	34.7	21.6	27.6	25.2	26.4
Gharnovka	1443	25.2	13.6	29.6	35.7	24.3	26.0	25.6	25.7
Pererodka	1350	29.8	12.0	25.5	32.7	21.7	25.0	23.0	24.3
Kubanka	1349	25.0	11.2	27.0	31.3	23.1	23.6	23.2	23.5
Yellow Gharnovka	1444	24.2	9.6	24.2	30.7	......	22.2	....	....
Velvet Don—Velvet Don	1445	16.8	9.7	27.6	24.1	......	19.6	....	....
Common:									
Preston—"Velvet Chaff," No. 13	......	......	7.5	19.2	32.3	18.7	....	19.4	....
Fife—Glyndon (Minn. No. 163)	2873	20.5	10.7	17.1	27.2	21.5	18.9	19.1	19.4
Bluestem—Haynes (Minn. No. 169)	2874	19.4	8.0	17.5	27.5	22.8	18.1	19.0	19.0

The best average yield of any spring common wheat is slightly lower than the lowest average yield of any durum wheat in the same period of years. Among the common varieties, Glyndon has the best 5-year average, 19.4 bushels per acre, while for the same period the average yield of Arnautka is 26.4 bushels per acre. All three of the standard spring common varieties are in close agreement in average yield during the 4-year and 5-year periods.

At Langdon there is more difference between the yields of the different durum wheats than is usually the case. All four of the varieties in the Kubanka group distinctly outyield Velvet Don. Within the Kubanka group, Arnautka (C. I. No. 1494) leads, outyielding Kubanka (C. I. No. 1349) by nearly 3 bushels per acre. These results substantiate further the results obtained at other stations in the Red River and Big Sioux valleys and territory adjacent thereto, showing the Arnautka variety to be best adapted to that section.

RESULTS AT DICKINSON, N. DAK.

The Dickinson substation of the North Dakota Agricultural Experiment Station is located on the border of the Heart River valley on a soil varying from sandy loam to clay loam. The elevation is 2,453 feet, and the average annual precipitation has been 15.7 inches in a 24-year period. The experiments were conducted cooperatively by the North Dakota Agricultural Experiment Station and the Office of Cereal Investigations.

The results will be found in Table XXII, and the principal data in graphic form in figure 12. Experiments have been in progress for 11 years, but the wheat crop of 1912 was destroyed by hail. Here, as elsewhere in the State, the durum varieties have outyielded all varieties of spring common wheat by quantities that are significant. Kubanka and Arnautka are the only durums grown throughout the 10-year period. Here Kubanka has proved a slightly better yielder than Arnautka. In a 5-year period the two excel all other durums. During a 7-year period they in turn have been outyielded by a pure-line selection of Kubanka (C. I. No. 1440). This selection, first known as Kubanka No. 8, is now known as Cereal Investigations No. 4063. In this period it had an average yield of 3.3 bushels greater than the parent Kubanka. In the last 4 years of the test all the varieties were exceeded in yield by the new and more rust-resistant variety, distributed as "D1" but now named Monad.[1]

Among the spring common wheats, Fife leads in yield, with Preston next and Bluestem last. Only Rysting and Haynes have been grown throughout the period. In the last four years Marquis has produced an average yield of 21.1 bushels, compared with 17.7 from Rysting, a gain of 3.4 bushels. In the same period, however, the yields of the four durums range from 25.5 bushels to 30.2 bushels per acre, so that Marquis does not equal durum in this district.

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[1] This name is derived from mona, the Greek word for one, plus *d*, which stands for durum. This variety was obtained in Russia by Prof. H. L. Bolley, of the North Dakota Agricultural Experiment Station, and was further selected by him at Fargo.

TABLE XXII.—*Annual and average yields of seven varieties of durum wheat and five varieties of common wheat grown at the Dickinson (N. Dak.) substation during periods of varying length from 1906 to 1916, inclusive.*[a]

[Data obtained in cooperation with the North Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).												
												Average.		
		1906	1907	1908	1909	1910	1911	1913	1914	1915	1916	4 years, 1913 to 1916.	5 years, 1906 to 1910.	9 years, 1906–1911 and 1913–1915.
Durum:														
Kubanka—														
Monad	3320	....	....	....	....	....	....	30.9	13.6	50.1	26.2	30.2	....	....
Kubanka	4063	....	....	....	43.2	19.9	3.5	31.2	13.0	51.5	17.4	28.3	....	....
Do	1440	28.8	36.0	23.5	33.7	14.9	3.8	26.7	14.2	46.8	16.6	26.1	27.4	24.5
Arnautka [b]	1494	24.3	26.4	22.8	37.0	23.4	[c]3.2	30.9	11.6	44.8	14.6	25.5	26.8	23.9
Pererodka	1350	27.3	28.4	18.8	36.0	23.0	....	....	....	....	....	....	26.7	....
Arnautka	1493	24.3	28.4	24.0	36.5	15.7	....	....	....	....	....	....	25.8	....
Yellow Gharnovka	1444	22.5	28.6	17.6	33.7	15.1	....	....	....	....	....	....	23.5	....
Common:														
Fife—														
Marquis	3641	....	....	....	....	....	....	24.2	14.0	32.8	13.5	21.1	....	....
Rysting	3022	22.0	17.6	22.3	33.0	20.7	7.7	28.1	12.4	25.6	4.5	17.7	23.1	19.4
Preston—Preston	3081	....	....	....	....	23.0	9.7	25.2	12.9	24.8	8.5	17.9	....	....
Bluestem—Haynes	2874	21.1	14.0	21.4	30.0	[d]13.1	8.6	24.8	8.3	22.9	3.1	14.8	19.9	16.7
Crimean (winter)—Beloglina	1543	....	....	....	....	....	....	9.1	9.2	0	18.7	9.3	....	....

[a] Crop of 1912 destroyed by hail.

[b] For 1906 to 1910, Arnautka (C. I. No. 1494); in 1913 to 1916, Arnautka 6P1 (C. I. No. 4064), a pureline selection from C. I. No. 1494, made at Akron, Colo.

[c] Not grown; yield computed from yield of Kubanka (C. I. No. 1400.)

[d] Destroyed by hail; yield computed from Crossbred Bluestem (C. I. No. 3314).

RESULTS AT WILLISTON, N. DAK.

The Williston substation of the North Dakota Agricultural Experiment Station is on a fine sandy loam soil in the valley of the Missouri River at an altitude of 1,875 feet. The normal annual rainfall is 14.9 inches. The experiments at Williston have been conducted cooperatively by the North Dakota Agricultural Experiment Station and the Office of Cereal Investigations.

The results of varietal trials with durum wheat and representative varieties of common wheat are presented in Table XXIII, and the leading data are shown graphically in figure 12. Six varieties of durum wheat, five of which belong to the Kubanka group, have been grown in periods varying from four to nine years. Velvet Don was outyielded by all varieties of the Kubanka group grown in the 6-year period from 1908 to 1912, inclusive. Kubanka and Arnautka are the only durum varieties grown throughout the 9-year period.

Kubanka has slightly outyielded Arnautka. It has excelled also in all periods all other durum varieties except a pure-line selection of Taganrog (C. I. No. 1570). This selection has been given Cereal Investigations No. 5295 and is here named Buford, to commemorate the Buford-Trenton Reclamation Project, in which the Williston substation is located. This wheat has outyielded all others included in Table XXIII during each of the last four years, with an average yield of 44.1 bushels, which is 1.6 bushels greater than that of Kubanka.

TABLE XXIII.—*Annual and average yields of six varieties of durum wheat and five varieties of common wheat grown at the Williston (N. Dak.) substation during periods of varying length in the nine years from 1908 to 1916, inclusive.*

[Data obtained in cooperation with the North Dakota Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).												
		1908	1909	1910	1911	1912	1913	1914	1915	1916	Average.			
											4 years, 1913 to 1916.	6 years, 1908 to 1913.	8 years, 1909 to 1916.	9 years, 1908 to 1916.
Durum:														
Kubanka—														
Buford	5295	.....	.....	.....	.....	.....	35.0	54.6	49.4	37.2	44.1	.....	.....	.....
Kubanka	1440	12.6	39.1	11.0	8.9	51.0	33.0	53.8	47.3	36.0	42.5	25.9	35.0	32.5
Arnautka	3693	15.6	37.4	6.1	8.2	49.7	34.7	47.2	45.5	37.4	41.2	25.3	33.3	31.3
Gharnovka	1447	15.8	35.5	9.3	10.5	46.0	34.8	.....	.....	.....	.....	25.3	.....	.....
Pererodka	1350	12.8	34.8	9.5	7.3	48.3	33.7	.....	.....	.....	.....	24.4	.....	.....
Velvet Don—Velvet Don	1445	15.6	36.8	3.7	8.9	43.3	25.0	.....	.....	.....	.....	22.2	.....	.....
Common:														
Fife—														
Marquis	3641	.....	.....	.....	.....	.....	29.0	52.5	40.6	35.0	39.3	.....	.....	.....
Power	3697	13.1	34.0	17.1	11.1	44.7	28.7	51.3	45.1	31.8	39.2	24.8	33.0	30.8
Bluestem—Dakota	3083	16.7	35.1	11.1	10.9	42.3	30.7	47.5	44.6	28.5	37.8	24.5	31.3	29.7
Preston—Preston	3698	.....	26.2	13.4	12.7	44.7	25.0	46.3	43.4	35.0	37.4	.....	30.8	.....
Crimean (winter)—Beloglina	1543	.....	40.0	9.9	26.5	0	7.8	10.0	12.8	34.2	16.2	.....	17.7	.....

The durum wheats have outyielded the leading varieties of Fife, Bluestem, Preston, and Crimean winter wheat in all the periods in which comparisons can be made. The lead of Kubanka over Power Fife, its nearest competitor in the common wheats, in the 8-year and 9-year periods is 2 bushels and 1.7 bushels, respectively, quantities which may be called fairly significant. It is probable that conditions in the valley where the station is located are slightly more favorable to common wheat than they are on the upland soil, which includes most of the farm land in that section of the State.

These results, covering a long period of years, together with those from Dickinson, N. Dak., and Highmore, Eureka, and Newell, S. Dak., show rather conclusively that Kubanka durum wheat is the variety best adapted to the central and western parts of North and South Dakota. A single year's test at Mandan, N. Dak., further supports this conclusion.

RESULTS AT MOCCASIN, MONT.

The Judith Basin, or Fergus County, substation, is located on a dark clay loam with a gravelly subsoil. The station has an altitude of 4,228 feet, and the average annual precipitation in the last 18 years has been 16.7 inches. Experiments there are conducted cooperatively by the Montana Agricultural Experiment Station and the Office of Cereal Investigations.

Data are presented in Table XXIV on experiments with durum wheat and the leading varieties of common wheat since 1908. The principal data are shown in graphic form in figure 12. Eleven varieties of durum wheat, belonging to four different groups, have been under experiment, though only two varieties have been grown continuously since 1908. The experimental crop of 1912 was destroyed by hail, so that the results of only eight years are available.

TABLE XXIV.—*Annual and average yields of eleven varieties of durum wheat and four varieties of common wheat grown at the Judith Basin substation, Moccasin, Mont., during periods of varying length in the nine years from 1908 to 1916, inclusive.*[a]

[Data obtained in cooperation with the Montana Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).										
		1908	1909	1910	1911	1913	1914	1915	1916	Average.		
										4 years, 1908 to 1911.	7 years, 1909–1911 and 1912–1916.	8 years, 1908–1911 and 1912–1916.
Durum:												
Pelissier—Pelissier	1584	10.0	41.0	10.5	28.3	32.0	26.5	42.2	28.7	22.5	29.9	27.4
Kubanka—												
Kubanka	1440	5.0	37.8	8.8	33.0	30.7	23.0	40.7	28.7	21.2	29.0	26.0
Pererodka	1350	5.0	36.7	12.7	36.0	32.0	25.3	40.1	......	22.6	......	......
Yellow Gharnovka	1444	15.0	39.3	8.2	27.7	32.8	25.0	39.2	......	22.5	......	......
Beloturka	1520	9.5	40.3	6.5	29.0	30.0	25.2	40.1	......	21.3	......	......
Arnautka	1494	10.0	33.0	7.6	31.7	......	......	......	......	20.6	......	......
Do	1493	10.0	36.7	10.0	25.0	......	......	......	......	20.4	......	......
Gharnovka	1447	5.0	35.8	10.0	30.3	......	......	......	......	20.3	......	......
Taganrog	1570	3.3	36.3	16.3	24.3	......	......	......	......	20.0	......	......
Kahla—Purple	3024	10.0	39.0	8.5	26.0	......	......	......	......	20.9	......	......
Velvet Don—Velvet Don	1445	7.5	32.3	6.1	26.0	......	......	......	......	18.0	......	......
Common:												
Crimean (winter)—Kharkof	1583	......	32.8	48.0	41.3	31.1	30.3	61.3	0	......	35.0	......
Fife—												
Marquis	3641	......	......	......	......	33.5	23.7	42.3	32.9	......	......	......
Rysting	3022	2.5	29.0	13.0	27.0	26.7	23.0	40.7	25.0	......	26.3	23.4
Preston—Preston	2958	......	31.0	13.5	25.0	29.2	22.4	41.6	[b]27.1	......	27.1	......
Bluestem—Haynes	3021	5.0	30.0	11.7	21.0	......	......	......	......	17.0	......	......

[a] The crop of 1912 was destroyed by hail.

[b] Yield of Preston, C. I. No. 3081, substituted.

The yields of all durum varieties are in rather close agreement. Pelissier has exceeded or equaled in yield all other varieties in all periods. Kubanka has ranked very close to Pelissier throughout. In the first four years, Kubanka was slightly excelled by Pererodka, Yellow Gharnovka, and Beloturka, in the order named.

Of the common wheats, Kharkof, of the Crimean group, outyielded even Pelissier in the 7-year period by 5 bushels, or 16 per cent. The leading spring common wheats are outyielded by the durums in quantities that are significant. Fife and Preston outyield Bluestem. Marquis, however, which was not included in the experiments until 1913, has an average yield of 33.1 bushels during the four years, compared with 28.8 bushels from Rysting Fife, 30.8 bushels from Kubanka, and 32.3 bushels from Pelissier. In these four years, therefore, it has outyielded not only the Fife wheat, but the two best durums as well. The durums, especially Pelissier, unquestionably are good wheats for this section. Marquis is as good and the hard red winter wheats are better than either.

Here, as at Akron, Colo., Pelissier has proved the best adapted of all durum wheats tested. These experiments, together with those at Archer, Wyo., and the result of a single year at Havre, Mont., indicate that Pelissier is the best-yielding durum wheat yet obtained for the drier western plains area having an altitude of 4,000 feet or more.

RESULTS AT BRANDON, MANITOBA.

The Brandon Experiment Farm is located on a sandy loam soil. Its altitude is 1,176 feet, and its average annual rainfall is 13 inches, according to a 9-year record. The station is maintained by the Canadian Department of Agriculture, and the data presented in Table XXV have been taken from the published annual reports (Canada Experimental Farms, 1896–1908).

TABLE XXV.—*Annual and average yields of three varieties of durum wheat and two varieties of common wheat grown on the Brandon (Manitoba) Experiment Farm during periods of varying length in the eleven years from 1895 to 1905, inclusive.*

Class, group, and variety.	Yield per acre (bushels).												
												Average.	
	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	2 years, 1904 and 1905.	11 years, 1895 to 1905.
Durum:													
Goose (Arnautka)	42.2	38.5	26.5	45.4	50.4	31.5	42.0	44.6	46.3	53.3	49.0	51.2	42.7
Yellow Gharnovka	......	......	......	......	......	......	......	......	......	45.0	54.0	49.5	......
Mahmoudi	......	......	......	......	......	......	......	......	......	44.6	46.6	45.6	......
Common:													
Fife—Red Fife	49.0	26.6	35.4	36.4	38.5	21.4	36.4	31.0	24.4	36.6	45.3	41.0	34.6
Preston—Preston	48.4	18.8	27.2	32.4	38.6	17.0	31.0	25.0	23.6	33.0	52.0	42.5	31.5

A variety of durum wheat was included in the experiments from 1895 to 1905. It was grown under the name Goose, but is probably the Arnautka variety. Two other varieties were included in the last two years. The resulting data from these and from representative varieties of the Fife and Preston groups are shown in graphic form in figure 12. In the 11-year period, the durum variety is seen to outyield Red Fife by 8.1 bushels and Preston by 11.2 bushels per acre.

RESULTS AT INDIAN HEAD, SASKATCHEWAN.

The Indian Head Experiment Farm has an average annual precipitation of 19.4 inches, based on a record covering 10 years. It is maintained by the Canadian Department of Agriculture, and the results given in Table XXVI are taken from the published annual reports (Canada Experimental Farms, 1896–1908).

Table XXVI.—*Annual and average yields of three varieties of durum wheat and two varieties of common wheat grown on the Indian Head (Saskatchewan) Experiment Farm during periods of varying length in the thirteen years from 1895 to 1907, inclusive.*

Class, group, and variety.	Yield per acre (bushels.)														
	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	Average.	
														4 years, 1904 to 1907.	13 years, 1895 to 1907.
Durum:															
Goose (Arnautka)	33.4	45.8	27.2	34.4	31.6	20.0	63.0	51.6	36.2	43.1	54.6	51.6	31.6	45.2	40.3
Mahmoudi	....	....	....	....	....	....	....	....	46.0	43.4	51.3	49.0	25.6	42.3	......
Yellow Gharnovka	....	....	....	....	....	....	....	....	......	41.7	52.0	52.6	29.3	43.9	......
Common:															
Preston—Preston	45.6	41.8	36.0	42.2	33.4	15.4	57.4	48.6	43.2	39.6	35.3	39.3	23.3	34.4	38.5
Fife—Red Fife	45.0	41.4	37.8	44.4	39.6	30.4	57.0	29.4	38.5	43.1	37.6	43.6	12.0	34.1	38.4

The experiments extend from 1895 to 1907, a period of 13 years. The same varieties are included as at Brandon, viz, a durum called Goose, probably Arnautka, with Preston and Red Fife, two spring common wheats. As at Brandon, two other durum varieties, Mahmoudi and Yellow Gharnovka, are included during the last five and four years, respectively. Arnautka outyielded the other two durums in the short period during which all were grown. In the 13-year period it outyielded Preston by 1.8 bushels and Red Fife by 1.9 bushels per acre. A market for durum wheat was not developed in Canada, so the wheat was not recommended for general cultivation by the Dominion Cerealist, and finally the varieties were discontinued from experimental tests.

RESULTS IN THE ARID BASIN AND COASTAL AREAS.

This geographic division includes most of the territory west of the Rocky Mountains. In the basin area are included the States and portions of States between the Rockies and the Sierra Nevada and

Cascade Ranges, excluding the humid portions of northern Idaho and northern Washington. The semiarid coastal area comprises only the two great interior valleys of California. The Willamette Valley of Oregon and the Puget Sound section of Washington are humid.

The chief agricultural lands of the basin area mostly lie at altitudes of 4,000 to 6,000 feet. This includes most of the dry-farmed districts in Utah, Idaho, Nevada, and Oregon, often called the Great Basin. It comprises the Salt Lake Basin of Utah, the Snake River Basin of Idaho, the Humboldt Basin of northern Nevada, the Harney Basin of southeastern Oregon, and the plateau region of central and southern Oregon, as well as territory adjacent to but perhaps not strictly included in any of these. The Columbia Basin of eastern Washington and north-central Oregon has an altitude of 1,000 to 2,000 feet. The San Joaquin and Sacramento Valleys of California lie much lower, the lower end of each reaching sea level and the upper portions being but a few hundred feet higher.

All these areas are characterized by low precipitation. Most of the rain falls during the autumn, winter, and spring months instead of during the summer, as in the Great Plains area. The seasonal rainfall is small in proportion to the total precipitation. For this reason, among others, winter wheats are more profitable and more extensively grown than spring-sown wheats. Crop production is governed almost wholly by the quantity and distribution of the annual precipitation. From Table II it will be seen that the annual rainfall of these stations, omitting only Chico, Cal., ranges from 9.5 to 13.5 inches.

Summer fallowing the land or allowing the fields to lie fallow in alternate years is the common farm and station practice in these areas. Summer tillage of the fallow to prevent the growth of weeds and volunteer grain conserves much of the moisture which falls in the year of fallow to help grow the crop in the succeeding year.

The soils of much of this area are of volcanic origin and are light in texture. Reference again to the data in Table II shows the soil at all six of the stations named to be either a sandy loam or a sandy clay loam.

Owing to the altitude, the growing season is short in much of this territory and early varieties are desirable. This also is another reason why winter varieties are more satisfactory. Even in the California valleys, with their low altitude and extremely long growing season, the intense heat and drought of midsummer make early varieties as important there as elsewhere.

The results from six stations in the arid basin and coastal areas are given in this bulletin. These stations are well scattered geographically, as will be seen from figure 13. They are also representative of the greatest extremes of altitude and precipitation, as will be noted from Table II (p. 15). Their altitude ranges from less than 100 feet to nearly 6,000 feet, and the precipitation ranges from 9.5 to 23.6 inches per annum.

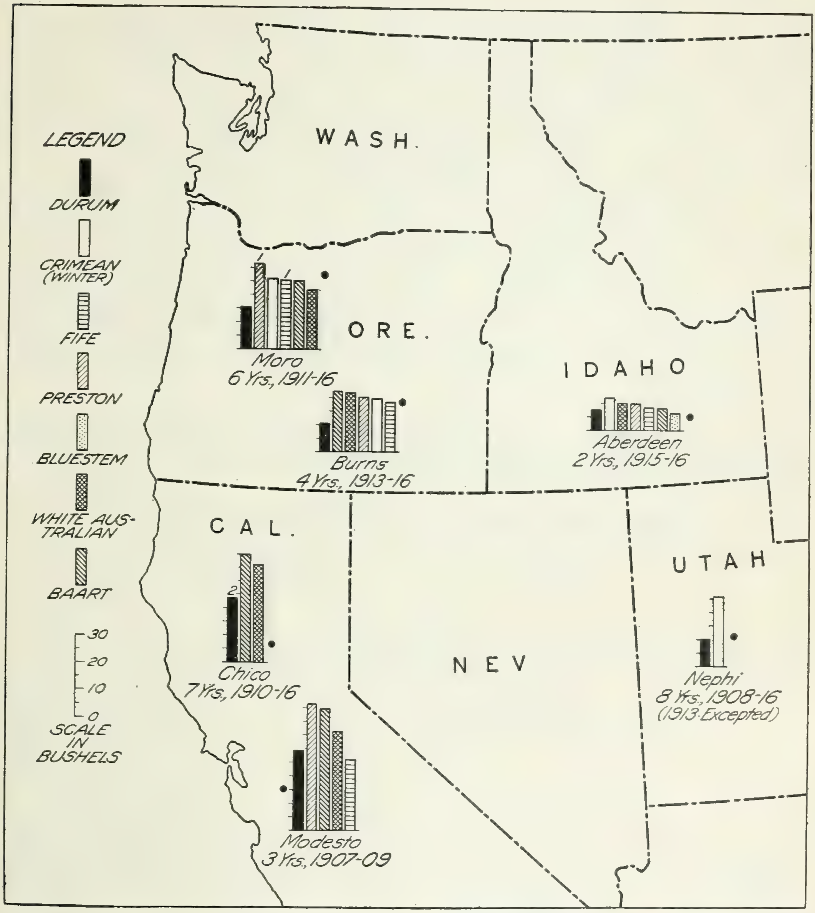

FIG. 13.—Diagram showing the location of six stations in the Great Basin and western coast areas and the average yield of the leading variety of durum wheat and the leading variety of each of several different groups of common wheat at each station during the periods of years indicated: 1, Average of only four years (Preston and Fife groups at Moro); 2, average of all varieties of durum wheat grown at Chico.

Durum wheats are not grown commercially anywhere in these areas. The leading wheats are the hard red winter varieties of the Crimean group and a number of soft red and soft white wheats, both winter and spring. None of them except the members of the Crimean group are varieties grown in the Great Plains area.

RESULTS AT NEPHI, UTAH.

The Nephi substation is located in Juab Valley in the eastern part of Juab County, Utah, near the summit of the Levan Ridge. This is a ridge of land a few miles in width, extending transversely across the valley floor south of the town of Nephi. The soil is a sandy clay loam. The altitude at the town of Nephi is 5,580 feet. The exact altitude of the substation on the ridge, 6 miles distant, is not known, but is thought to be nearly 6,000 feet. The average annual precipitation is 13.5 inches in a 17-year period. The experiments at Nephi were conducted cooperatively by the Utah Agricultural Experiment Station and the Office of Cereal Investigations.

The experiments began in 1908 and cover a period of eight years, no durum wheats having been grown in 1913. The results of varietal experiments with four durum wheats and one winter common wheat are shown in Table XXVII. The principal data are presented graphically in figure 13. One of the durum varieties was tested for only five years, but data on all of the others are available for the full 8-year period.

TABLE XXVII.—*Annual and average yields of four varieties of durum wheat and one variety of common wheat grown at the Nephi (Utah) substation during periods of varying length in the nine years from 1908 to 1916, inclusive.*[a]

[Data obtained in cooperation with the Utah Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).									
										Average.	
		1908	1909	1910	1911	1912	1914	1915	1916	5 years, 1908 to 1912.	8 years, 1908–1912 and 1914–1916.
Durum:											
Kubanka—Kubanka	1440	10.0	11.5	2.0	7.3	5.3	15.7	18.2	15.0	7.2	10.2
Pelissier—											
Adjini	1594	12.5	7.8	2.2	5.5	4.1	19.0	15.3	12.7	6.4	9.9
Mohamed ben Bachir	2087	8.0	8.8	2.2	6.0	6.3	18.5	14.2	14.2	6.3	9.8
Kahla—Kahla	2088	12.0	9.7	3.2	7.0	6.6	......	......	......	7.7	......
Common:											
Crimean (winter)—Crimean	1437	30.3	18.7	20.3	26.7	19.5	40.3	29.4	23.0	23.1	26.0

[a] Durum wheats were not grown in 1913.

In the five years from 1908 to 1912, inclusive, Kahla, a black-glumed variety, slightly outyielded the other three durums. It was not grown longer. In the eight years, Kubanka excelled the two little-known varieties of the Pelissier group by a small fraction of a bushel. The durum yields are all low, however, the best annual yield recorded being only 19 bushels per acre. The winter precipitation and short growing season both favor winter wheats. It is not surprising, therefore, to find the 8-year average yield of Crimean hard red winter wheat to be 26 bushels, or an increase of 150 per cent over that of Kubanka. Durum wheats were also tested at this station from fall sowing, but the yields obtained were no larger than from spring sowing.

RESULTS AT ABERDEEN, IDAHO.

The Aberdeen substation is located in the Snake River Plains of southern Idaho on a sandy clay-loam soil containing some volcanic-ash material. The altitude is 4,400 feet. The average annual precipitation in the past four years has been only 9.5 inches, the lowest recorded for any of the stations west of the Rocky Mountains. The substation is maintained cooperatively by the Idaho Agricultural Experiment Station and the Office of Cereal Investigations.

The results obtained at Aberdeen are found in Table XXVIII and the principal data in graphic form in figure 13. Data on durum wheats are available for only the last two years. These wheats are compared with a representative variety from each of six different groups of spring wheat and the Crimean group of winter wheat. The average yields of all varieties are low in this 2-year period. Only three out of nine varieties exceed 10 bushels per acre. The yields of the durum are below the general average, being exceeded, or at least equaled, by five of the six spring common varieties. Although data for only two years are not conclusive, there is little reason for expecting the durum varieties to be worthy of being grown in the Snake River Basin.

TABLE XXVIII.—*Annual and average yields of five varieties of durum wheat and seven varieties of common wheat grown at the Aberdeen (Idaho) Branch Experiment Station during 1915 and 1916.*

[Data obtained in cooperation with the Idaho Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).			Class, group, and variety.	C. I. No.	Yield per acre (bushels).		
		1915	1916	Average.			1915	1916	Average.
Durum:					Common—Continued.				
Kubanka—					White Australian—				
Arnautka	4064	7.2	8.3	7.8	Pacific Bluestem	4067	9.0	12.3	10.7
Do	1493	4.5	......	....	Preston—Fretes	1596	10.8	9.7	10.3
Kubanka	1516	6.3	8.7	7.5	Fife—Marquis	3276	6.3	11.3	8.8
Beloturka	1520	5.4	......	....	Baart—Early Baart	1697	7.5	9.7	8.6
Pelissier—Pelissier	1584	6.3	......	....	Little Club—Little Club	4066	7.2	8.3	7.8
Common:					Bluestem—Haynes	2874	5.4	8.0	6.7
Crimean (winter)—									
Kharkof	1442	21.1	3.5	12.3					

The 2-year average yield of the Crimean variety Kharkof also is low, although its 12.3 bushels is the highest average of all. This is lower than observation and experience show may reasonably be expected from these wheats in this section.

RESULTS AT BURNS, OREG.

The Harney Branch Experiment Station is located near the town of Burns in the bed of an ancient lake now known as the Harney Valley. The soil varies from a silt loam to a very fine sandy loam. The altitude of the station is 4,100 feet, which is about that of the valley floor and lower than that of the plateau of south-central Oregon. The average annual precipitation during the past 12 years has been 11.7 inches. The station is conducted cooperatively by the Oregon Agricultural Experiment Station and the Office of Cereal Investigations.

The station was established in 1912, and the first crop was grown in 1913. Data covering the experiments of four years are given in Table XXIX. The principal facts are illustrated in figure 13. Four durum varieties were grown during the first three years, but only one of these, Kubanka, C. I. No. 1354, was continued in 1916. In the 3-year period, Kubanka, C. I. No. 1354, was outyielded by all three of the other durums, the lead of Marouani being 3.7 bushels. In the same period Marouani was exceeded by all five varieties of common wheat in quantities ranging from 5 to 10 bushels per acre. The same fact holds true in the 4-year average, where Kubanka is the only durum and the yields of the common wheat exceed that of Kubanka by 8 to 11.5 bushels per acre.

TABLE XXIX.—*Annual and average yields of four varieties of durum wheat and seven varieties of common wheat grown at the Harney Branch Experiment Station, Burns, Oreg., during periods of varying length in the four years from 1913 to 1916, inclusive.*

[Data obtained in cooperation with the Oregon Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).					
		1913	1914	1915	1916	Average.	
						3 years, 1913 to 1915.	4 years, 1913 to 1916.
Durum:							
Kubanka—							
Marouani	1593	22.7	7.2	16.0	......	15.3	....
Yellow Gharnovka	1444	22.8	6.0	13.3	......	14.0	....
Kubanka	2246	17.0	8.0	15.3	......	13.4	....
Do	1354	13.2	6.0	15.7	7.7	11.6	10.7
Common:							
Baart—Early Baart	1697	28.3	18.2	26.2	16.1	24.2	22.2
White Australian—Pacific Bluestem	4067	32.0	16.7	23.6	15.6	24.1	22.0
Crimean (winter)—Turkey	1558	26.0	19.3	30.7	4.0	25.3	20.0
Fife—							
Ghirka Spring	1517	25.3	15.7	20.5	13.4	20.5	18.7
Marquis	......	......	9.3	21.3	14.3	....	....
Preston—Fretes	1596	28.0	13.3	20.0	......	20.4	....

Among the common wheats, Early Baart and Pacific Bluestem, two soft white wheats, outyielded the red-kerneled spring wheats of the Great Plains area. The hard red winter wheats are a somewhat precarious crop in this district and are not able to outyield the best spring varieties of common wheat. Durum varieties are evidently not suitable for growing in this valley.

RESULTS AT MORO, OREG.

The Eastern Oregon Dry-Farming Substation is located in Sherman County, on the rolling hills of the Columbia Basin, at an average altitude of 1,800 feet. The soil is a silt loam. The average annual rainfall has been 11.3 inches in the past 11 years. The station is operated cooperatively by the Oregon Agricultural Experiment Station and the Office of Cereal Investigations.

The yields obtained from 1911 to 1916, inclusive, are shown in Table XXX, and the principal facts are portrayed in figure 13. Only two durum varieties have been grown throughout this period. Their yields, while good, still are lower than those of any variety of common wheat shown. This is true in both the 4-year and the 6-year periods. The Turkey hard red winter wheat is the best of all, closely followed by Early Baart and Koola. These latter two varieties are both bearded wheats, the first one with white, the other with red kernels. Durum wheats are not likely to become important in the Columbia Basin on the basis of the showing made.

TABLE XXX.—*Annual and average yields of two varieties of durum wheat and six varieties of common wheat grown at the Eastern Oregon Dry-Farming Substation, Moro, Oreg., during periods of varying length in the six years from 1911 to 1916, inclusive.*

[Data obtained in cooperation with the Oregon Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).							
		1911	1912	1913	1914	1915	1916	Average.	
								4 years, 1913 to 1916.	6 years, 1911 to 1916.
Durum:									
Kubanka—									
Kubanka	1440 1516	11.0	16.2	16.0	21.5	18.0	29.5	21.3	18.7
Blé Noir	2511-2	3.5	7.5	18.0	18.3	23.6	37.2	24.3	18.0
Common:									
Preston—Koola	2203-2	......	......	25.8	24.5	33.2	44.6	32.0	....
Crimean (winter)—Turkey	1558	9.0	20.6	24.0	27.5	20.6	55.0	31.8	26.1
Baart—Early Baart	1697	14.5	19.0	25.0	26.0	26.6	41.0	29.7	25.4
Little Club—Little Club	4068	13.1	22.6	19.6	19.2	26.0	42.3	26.8	23.8
Fife—Marquis	4158	......	......	22.1	22.5	23.1	35.3	25.8	....
White Australian—Pacific Bluestem	4067	11.7	20.1	19.4	20.9	24.0	37.3	25.4	22.2

RESULTS AT CHICO, CAL.

The Chico Plant Introduction Garden is located in the Sacramento Valley, at an altitude of 189 feet, on a sandy loam soil containing some gravel. The normal annual precipitation is 23.6 inches, according to the records of 45 years. The garden is maintained by the Office of Foreign Seed and Plant Introduction of the Bureau of

Plant Industry, and the cereal experiments are conducted in cooperation therewith by the Office of Cereal Investigations. Data resulting from experiments conducted in the years 1910 to 1916, inclusive, are given in Table XXXI, and the principal facts are shown graphically in figure 13.

TABLE XXXI.—*Annual and average yields of ten varieties of durum wheat and two varieties of common wheat grown at the Plant Introduction Garden, Chico, Cal., during periods of varying length in the seven years from 1910 to 1916, inclusive.*

[Data obtained in cooperation with the Office of Foreign Seed and Plant Introduction.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).								
		1910	1911	1912	1913	1914	1915	1916	Average.	
									2 years, 1910 and 1911.	7 years, 1910 to 1916.
Durum:										
Kubanka—										
Kubanka	2246	19.7	36.3	......	......	......	......	......	28.0	....
Yellow Gharnovka	2096	9.6	36.6	......	......	26.2	......	......	23.1	....
Marouani	1593	[a]10.7	34.6	......	......	......	......	......	22.7	....
Kubanka	1440	[a]8.5	29.6	......	[a]29.5	......	......	......	19.1	....
Do	2221	2.5	32.3	......	......	......	......	......	17.4	....
Unnamed	1595	......	......	21.3	......	21.3	18.0	22.0	....	....
Arnautka	1494	......	......	25.0	32.3	19.0	......	......	....	....
Cavarna	2575	......	......	30.0	29.7	......	......	......	....	....
Velvet Don—Velvet Don	2227	20.0	33.3	......	......	......	......	......	26.7	....
Kahla—										
Unnamed	2235-2	......	......	26.3	34.8	27.7	......	20.1	....	....
Average of all durums	......	11.8	33.8	25.7	31.6	23.6	18.0	21.1	....	23.7
Common:										
Baart—Early Baart	1697	39.3	90.6	27.5	45.7	30.2	19.2	27.5	65.0	40.0
White Australian—White Australian	3019	28.0	65.5	[b]31.5	[c]44.7	[b]34.7	18.6	32.0	46.8	36.4

[a] Average of two plats.
[b] Average of six plats.
[c] Average of seven plats.

All varieties are fall sown at Chico, and all are grown on summer-fallowed land. No less than 10 different durum varieties have been tested during the seven years, but none of them for more than three years consecutively. For this reason it is almost impossible to arrive at comparable average yields. However, only a glance is needed to show that the durums are all greatly outyielded by the two representative varieties of common wheat. This is true, in spite of the fact that some good yields were obtained from the durum varieties. In the comparison made between yields of durum and varieties of two groups of common wheat in figure 13, the average yield of all varieties of durum wheat grown is used.

RESULTS AT MODESTO, CAL.

The Modesto substation was located in the lower San Joaquin Valley at an altitude of 90 feet. The soil is the sandy loam characteristic of the valley. The average annual precipitation is 10.5

inches on the basis of 44-year records. The substation was established to conduct experiments with cereals and was maintained cooperatively by the California Agricultural Experiment Station and the Office of Cereal Investigations.

TABLE XXXII.—*Annual and average yields of six varieties of durum wheat and four varieties of common wheat grown at the Modesto (Cal.) substation during periods of varying length in the three years from 1907 to 1909, inclusive.*

[Data obtained in cooperation with the California Agricultural Experiment Station.]

Class, group, and variety.	C. I. No.	Yield per acre (bushels).				
					Average.	
		1907	1908	1909	2 years, 1908 and 1909.	3 years, 1907 to 1909.
Durum:						
Kubanka—						
Marouani	2235	9.7	44.7	33.3	39.0	29.3
Kubanka	2221	......	26.8	26.5	26.7	....
Do	2246	......	30.8	21.8	26.3	....
Yellow Gharnovka	2096	......	31.8	18.0	24.9	....
Velvet Don—Velvet Don	2247	7.4	32.8	14.2	23.5	18.1
Pelissier—Medeah	1597	......	32.8	13.3	23.1	....
Common:						
Preston—Fretes	1596	16.2	67.3	56.0	61.7	46.5
Baart—Propo	1970	9.0	69.3	55.0	62.2	44.4
White Australian—White Australian	3019	13.1	51.3	44.0	47.7	36.1
Fife—Power	2989	6.7	33.2	39.1	36.2	26.3

The yields obtained in experiments continued for three years, 1907 to 1909, inclusive, are shown in Table XXXII, and the principal facts are shown graphically in figure 13. Six varieties of durum wheat, belonging to three separate groups, were included during two years, and two of them during all three years. Four varieties of common wheat, two with hard red kernels and two with soft white kernels, were compared with the durum varieties. Among the durums, Marouani easily takes first place. Here, as at Chico, however, only a glance is needed to show the marked superiority of the common wheats. As at other points west of the Rocky Mountains, durum varieties are not the best adapted wheats for growing in California.

SUMMARY OF RESULTS.

The average yield of the highest yielding durum wheat at each of the 30 stations discussed in this bulletin is presented in Table XXXIII. In parallel columns is shown the average yield of the best variety in each of the groups of common wheat, both winter and spring, which were grown at the stations in the same period of years. The length of the periods is shown in the second column.

TABLE XXXIII.—*Average yields of the highest yielding variety of durum wheat and the highest yielding variety in one or more of six different groups of common wheat grown at thirty experiment stations in the western United States and Canada under humid, semi-arid, and arid conditions during some of the twenty-two years from 1895 to 1916, inclusive.*

SECTION 1.—YIELD PER ACRE OF THE BEST VARIETY IN EACH GROUP (BUSHELS).

Area and station.	Number of years grown.	Durum.	Crimean (winter).	Fife.	Preston.	Bluestem.	White Australian.	Baart.
Prairie (subhumid area):								
McPherson, Kans	6	12.6	23.2	....	....	....	....	....
Manhattan, Kans	3	12.6	40.1	[a] 7.5	[a] 4.5	[a] 6.6	....	....
Lincoln, Nebr	1	16.5	33.2	....	....	....	....	....
Ames, Iowa	5	21.5	34.5	[b] 26.7	24.9	22.7	....	....
Brookings, S. Dak	12	19.7	[c] 23.9	12.7	16.2	12.1	....	....
Ashland, Wis	4	23.0	[b] 23.6	20.0	[b] 18.2	24.9	....	....
St. Paul, Minn	4	31.6	[b] 46.0	36.5	34.9	30.9	....	....
Crookston, Minn	5	25.7	....	23.8	20.5	20.1	....	....
Fargo, N. Dak	7	35.9	....	24.7	[d] 23.9	28.3	....	....
Great Plains (semiarid area):								
Amarillo, Tex	11	9.5	12.4	....	9.1	....	....	....
Hays, Kans	14	3.8	14.6	....	....	....	....	....
Akron, Colo	9	21.5	21.6	17.6	16.9	....	....	....
North Platte, Nebr	5	12.2	22.1	10.7	6.4	....	....	....
Archer, Wyo	4	13.6	15.0	10.9	12.1	7.5	....	....
Highmore, S. Dak	12	16.2	[e] 17.8	11.5	13.5	11.2	....	....
Eureka, S. Dak	8	13.9	....	[b] 17.5	7.6	6.5	....	....
Newell, S. Dak	9	17.2	26.0	13.1	[f] 12.6	12.0	....	....
Edgeley, N. Dak	11	21.5	....	14.9	[g] 14.4	15.0	....	....
Langdon, N. Dak	5	26.4	....	19.4	[d] 19.4	19.0	....	....
Dickinson, N. Dak	10	24.5	[d] 9.3	19.4	[g] 17.4	16.7	....	....
Williston, N. Dak	8	35.0	17.7	33.0	30.8	31.3	....	....
Moccasin, Mont	7	29.9	35.0	26.3	27.1	[d] 17.0	....	....
Brandon, Manitoba	11	42.7	....	34.6	31.5	....	....	....
Indian Head, Saskatchewan	13	40.3	....	38.4	38.5	....	....	....
Western basin and coast (arid area):								
Nephi, Utah	8	10.2	26.0	....	....	....	....	....
Aberdeen, Idaho	2	7.8	12.3	8.8	10.3	6.7	10.7	8.6
Burns, Oreg	4	10.7	20.0	18.7	[b] 20.4	....	22.0	22.2
Moro, Oreg	6	18.7	26.1	[d] 25.8	[d] 32.0	....	22.2	25.4
Chico, Cal	7	[h] 23.7	....	....	....	....	36.4	40.0
Modesto, Cal	3	29.3	....	26.3	46.5	....	36.1	44.4

SECTION 2.—YIELD PER ACRE EXPRESSED AS A PERCENTAGE OF THE YIELD OF DURUM.

Area and station.	Number of years grown.	Durum.	Crimean (winter).	Fife.	Preston.	Bluestem.	White Australian.	Baart.
Prairie (subhumid area):								
McPherson, Kans	6	100	184.2	....	....	....	....	....
Manhattan, Kans	3	100	318.0	[a] 61.5	[a] 36.9	[a] 54.1	....	....
Lincoln, Nebr	1	100	201.0	....	....	....	....	....
Ames, Iowa	5	100	160.5	[b] 126.5	115.8	105.6	....	....
Brookings, S. Dak	12	100	[c] 108.1	64.5	82.3	61.4	....	....
Ashland, Wis	4	100	[b] 100.8	87.0	[b] 77.8	108.2	....	....
St. Paul, Minn	4	100	[b] 136.8	115.5	110.3	97.7	....	....
Crookston, Minn	5	100	....	92.6	79.8	78.2	....	....
Fargo, N. Dak	7	100	....	68.8	[d] 66.6	78.9	....	....
Great Plains (semiarid area):								
Amarillo, Tex	11	100	130.5	....	95.8	....	....	....
Hays, Kans	14	100	384.3	....	....	....	....	....
Akron, Colo	9	100	100.5	81.9	78.6	....	....	....
North Platte, Nebr	5	100	181.0	87.7	52.4	....	....	....
Archer, Wyo	4	100	110.2	80.2	89.0	55.2	....	....
Highmore, S. Dak	12	100	[e] 130.0	71.0	83.4	69.2	....	....
Eureka, S. Dak	8	100	....	[b] 84.2	54.6	46.8	....	....
Newell, S. Dak	9	100	151.1	76.2	[f] 81.3	69.8	....	....
Edgeley, N. Dak	11	100	....	69.3	[g] 83.7	69.8	....	....
Langdon, N. Dak	5	100	....	73.5	[d] 77.0	72.0	....	....
Dickinson, N. Dak	10	100	[d] 35.6	79.2	[g] 84.9	68.2	....	....
Williston, N. Dak	8	100	50.6	94.3	88.0	89.4	....	....
Moccasin, Mont	7	100	117.1	88.0	90.7	[d] 75.6	....	....
Brandon, Manitoba	11	100	....	81.0	73.8	....	....	....
Indian Head, Saskatchewan	13	100	....	95.3	95.5	....	....	....
Western basin and coast (arid area):								
Nephi, Utah	8	100	254.8	....	....	....	....	....
Aberdeen, Idaho	2	100	157.7	112.8	132.1	85.9	137.2	110.2
Burns, Oreg	4	100	186.8	174.8	[b] 175.8	....	205.5	207.3
Moro, Oreg	6	100	139.5	[d] 121.1	[d] 150.2	....	118.7	135.8
Chico, Cal	7	[h] 100	....	....	....	....	153.6	168.7
Modesto, Cal	3	100	....	89.8	158.6	....	123.2	151.6

[a] Average for 2 years only.
[b] Average for 3 years only.
[c] Average for 10 years only.
[d] Average for 4 years only.
[e] Average for 5 years only.
[f] Average for 7 years only.
[g] Average for 6 years only.
[h] Average of all durum varieties grown.

Section 1 of Table XXXIII shows the actual average acre yields obtained from each wheat. Section 2 shows the same data expressed in percentages. The yield of the best durum variety is taken as 100 per cent in each case. The data in this table are the same as those shown graphically in figures 8, 12, and 13.

The actual performance is seen more readily in the first section of the table, where yields are given in bushels per acre. The comparative performance, which indicates in large measure the comparative value, is seen much more readily in the second section of the table, where the results are expressed in percentages. After the detailed presentation of these data in Tables III to XXXII, inclusive, only a brief summary seems necessary.

THE SUBHUMID PRAIRIE AREA.

In studying the summarized results from the nine stations in the subhumid prairie area, certain facts stand out plainly, as will be seen in Table XXXIII.

(1) In general, the durum wheats are not adapted to the humid conditions often obtaining in the eastern part of this area, but they do comparatively well in the subhumid northwestern part.

(2) In the southern part of the prairie area, which includes the eastern portions of Kansas and Nebraska, neither durum nor common spring wheats do well.

(3) Wherever the hard red winter wheats of the Crimean group can be grown they greatly outyield any spring wheat.

(4) In the northeastern portion of this area, under the conditions obtaining at Ashland, Wis., and St. Paul, Minn., winter wheat is reaching the northern limits of its present culture and is not so outstandingly superior. The durum wheats are equal in yield to some of the common wheats and poorer than others. The value of the durums will depend on the quality of their grain and the need which exists for their rust resistance.

(5) In the northwestern portion of this area, including the western part of Minnesota and the eastern parts of the Dakotas, the durum wheats have a much higher comparative value. They largely outyield the spring common wheats and nearly equal winter wheat in the districts where it can be grown at all.

(6) Of the varieties of durum wheat tested Arnautka is best adapted for growing in western Minnesota and the eastern portions of the Dakotas.

THE GREAT PLAINS AREA.

A study of the summarized results from 15 stations in the Great Plains area, shown in part in Table XXXIII, supports the following conclusions:

(1) Durum wheats produce very well in all but the southern part of this large area.

(2) No spring wheats do well in the southern part of the Great Plains.

(3) Wherever the hard red winter wheats of the Crimean group can be grown commercially they are better yielders than any spring wheat. In the higher and drier parts of the plains of Colorado and Wyoming and in central South Dakota their advantage is very small.

(4) In the central and northern parts of this area, wherever spring wheat is commercially important, durum exceeds spring common wheat in yield almost without exception. Usually this is by a large margin, of 10 to 30 per cent, but occasionally by as little as 5 per cent.

(5) Of all the varieties of durum wheat tested in this area, the Kubanka is best adapted to all the varying conditions. It is most suitable for central and western North and South Dakota and eastern Montana, at altitudes ranging from 1,800 to 4,000 feet. The Arnautka is slightly better adapted to the more humid eastern part of the Northern Plains with altitudes ranging from 1,000 to 1,800 feet. The Pelissier is a better yielder in the western and drier sections at altitudes of 4,000 to 6,000 feet.

(6) A number of pure-line selections of durum wheat are proving better adapted to the local conditions where they were developed than are the older standard varieties. Three which differ appreciably from the standard varieties from which they were selected have been named. Five of these races appear to be of sufficient value to be tested under a wide range of conditions. They are as follows: Acme (C. I. No. 5284), a selection from Kubanka (C. I. No. 1516) made at Highmore, S. Dak.; Arnautka (C. I. No. 4064) a selection from Arnautka (C. I. No. 1494) made at Akron, Colo.; Monad (C. I. No. 3320), a selection made from a field in Russia but tested at Dickinson, N. Dak.; Buford (C. I. No. 5295), a selection from Taganrog (C. I. No. 1570) made at Williston, N. Dak.; Kubanka No. 8 (C. I. No. 4063), a selection from Kubanka (C. I. No. 1440) made at Dickinson, N. Dak. Of these five, Acme and Monad are very rust resistant.

THE ARID BASIN AND COASTAL AREAS.

A study of the data from the six stations located in these western areas, as summarized in Table XXXIII, shows two facts definitely.

(1) Except for the Crimean group of winter wheats, the standard varieties of the western areas differ from those of the Great Plains and Prairie States.

(2) In these areas the better yields have been obtained from hard red winter wheats of the Crimean group or from some variety of soft white wheat.

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